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UNIVERISTY OF ALBERTA

A Model of a Mid-Block Pedestrian Signal Within a Fixed Time Traffic Signal System

by

Gary Edwin Vlieg

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF:
Master of Science

Deparment of Civil Engineering

Edmonton, Alberta
Fall 1991

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for Acceptance, a thesis entitled "A Model of a Mid-Block Pedestrian Signal Within a Fixed Time Traffic Signal System" submitted by Gary Edwin Vlieg in partial fulfillment of the requirements for the degree of Master of Science.

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Date: June 24, 1991

To:

Laurel

and to

Dad, Mom, Karen and Sid

ABSTRACT

A mid-block pedestrian traffic signal is an important traffic control device to allow pedestrians to safely cross a busy roadway. There are few methods by which the impact, on vehicles and pedestrians, of such a traffic control device can be determined. No traffic operations model allows for the direct simulation of such a traffic signal. This paper presents the theoretical background, the PEDXING computer program and the program results used to develop a model of a mid-block pedestrian traffic signal within a fixed-time traffic signal system. The output of the model is the average delay for vehicles and the average delay for pedestrians as a principal measure of effectiveness of the system operation.

EXECUTIVE SUMMARY

The primary concern of any transportation professional is to provide for the efficient movement of persons and goods from point A to point B. To attain that goal it is vital to maintain the public safety within the transportation network regardless of the mode of travel used. A secondary consideration is to minimize the delay to traffic, whether it be pedestrian or vehicle. The difficulty lies in trying to balance safety against delay when resolving conflicts between opposing streams or modes of traffic.

One of the most common problems is the conflict between pedestrians and vehicles attempting to utilize the same space at the same time. Various techniques have been devised to mitigate this conflict ranging from a marked (painted) crosswalk to a full traffic signal. Each type a pedestrian crossing treatment has a significant and measurable impact on both pedestrians and vehicles.

No traffic operations model is currently capable of directly modelling a mid-block pedestrian signal to ascertain both vehicle and pedestrian delay. Typically, traffic operations models accommodate the random activations of a pedestrian signal by adjusting the input data to model the pedestrian as vehicles at a traffic activated signal. This thesis describes the principles and functions used to develop a computer simulation model that determines the delays incurred by both vehicles and pedestrians as a result of a mid-block pedestrian signal located between two fixed-time traffic signals.

The model uses the following assumptions: the vehicle arrival pattern at the first signal is based on the shifted exponential distribution; the pedestrian arrival pattern is based on the negative exponential distribution; pedestrians and vehicles will not violate the signals; there are three consecutive traffic signals with no intervening traffic control devices; and, vehicles travel at a uniform and constant speed with instantaneous acceleration and

deceleration. The model also assumes that the network is under-saturated i.e. the volume-to-capacity ratio is below 0.80 in order to discount the effects of constant overflow delay.

The program processes the vehicles through the first intersection calculating the average vehicle delay. The vehicles are then processed through the pedestrian crossing, incurring delay only if pedestrians have activated the signal. The vehicles are finally processed through the second intersection, again calculating the average delay per vehicle. Pedestrians arrive at the pedestrian crossing entering a call to the signal controller. If the minimum vehicle green has been exceeded and the timing is co[illegible] the case when the signals are coordinated, the pedestrians are allowed to proceed [illegible] the crosswalk and the average pedestrian delay is calculated. The program includes a module to print the time-space diagram for the vehicles in order to assist the analyst in assessing the impact of the mid-block pedestrian signal on vehicle flow.

Two sets of field data were collected to verify the model. The program was run with input based on field data and the program output was compared to the results of the data collected. The model yielded favourable results. The model can now be used as an instrument to develop guidelines for the inclusion or exclusion of a mid-block pedestrian signal into a coordinated signal system. The program can also be used to evaluate the impact of changes to system parameters such as volumes, saturation flows, geometrics and signal timings

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Shortly before graduating from the University of Alberta (1986), Professor John Bakker encouraged the Author to continue his education and obtain a Master of Science degree in Transportation Engineering in order to further his technical expertise in the field.

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TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1

1.1 Motivation for Research 1

1.2 Problem Statement 1

1.3 Thesis Objective 2

1.4 Scope of the Research 2

1.5 Organization of Thesis 4

2.0 LITERATURE REVIEW 5

2.1 Overview of Past Research Efforts 5

2.2 Pedestrian Crossings 5

2.3 Isolated Pedestrian Signal 6

2.4 Pedestrian Crossing Facilities and Delay 9

2.5 Pedestrian Crossing Facilities within a Linked Signal System 9

2.6 Pedestrian On-line Operation Determination 13

2.6.1 Major Road Traffic Volume Index 13

2.6.2 Effectiveness of Coordination Index 14

2.6.3 Arrival Pattern Index 14

2.6.4 Bus/Pedestrian Index 14

2.6.5 Route Coordination Index 15

2.6.6 Summary 15

TABLE OF CONTENTS continued

Page

2.7 Isolated Intersection Pedestrian Calculations 15
2.8 Pedestrian Delay at Signalized Intersections 16
  2.8.1 Australia 16
  2.8.2 Highway Capacity Manual 18
2.9 Transportation Models and Pedestrians 18
  2.9.1 NETSIM 18
  2.9.2 TRANSYT 19
  2.9.3 CONTRAM 20
  2.9.4 Summary 20
2.10 Coordination 20
2.11 Summary 21

3.0 THEORETICAL BACKGROUND 23
3.1 Introduction 23
3.2 Headway Distribution 23
  3.2.1 Probabilistic versus Deterministic Arrival Patterns 23
  3.2.2 Types of Distributions 24
    Negative Exponential Distribution 24
    Shifted Negative Exponential Distribution 26
    Erlang Distribution 28
    Hyperlang Distribution 28
    Summary 31

TABLE OF CONTENTS continued

Page

3.3 Delay 31
  3.3.1 Uniform and Overflow Delay 31
  3.3.2 Delay Measurement 32
3.4 Pedestrian Behaviour 35
  3.4.1 Signal Obeyance 35
  3.4.2 Signal Activation 36
  3.4.3 Grouping 36
  3.4.4 Climate/Weather 36
  3.4.5 Delay 37
  3.4.6 Geometrics 38
  3.4.7 Summary 38

4.0 SYSTEM PRINCIPLES 39
  4.1 Introduction 39
  4.2 Vehicle Trajectories 40
  4.3 Signal Timings 40
  4.4 Signal Coordination 42
  4.5 Arrival Distribution 45
  4.6 Summary 48

5.0 COMPUTER MODEL 49
  5.1 Introduction 49
  5.2 Overall Program Structure 49

TABLE OF CONTENTS continued

		Page
5.3	Previous Models	53
5.4	Model Assumptions	54
	5.4.1 Introduction	54
	5.4.2 V/C Ratio	54
	5.4.3 On-Turning Traffic	54
	5.4.4 Legal Requirements	55
	5.4.5 Pedestrian Crosswalk	55
	5.4.6 Vehicle Headways	55
	5.4.7 Pedestrian Headways	56
	5.4.8 Vehicle Operation	56
5.5	Detailed Model Description	56
	5.5.1 Introduction	56
	5.5.2 Random Number Generator	56
	5.5.3 Vehicle Headway Distribution	57
	5.5.4 Pedestrian Headway Distribution	58
	5.5.5 On-Turn Vehicle Headways	58
	5.5.6 Operation of Vehicle Signal	59
	5.5.7 Operation of the Pedestrian Signal	60
5.6	Model Input	62
	5.6.1 Through Volume	63
	5.6.2 On-Turning Volume	65
	5.6.3 Stopline Saturation Flow	65

TABLE OF CONTENTS continued

Page

5.6.4 Simulation Duration 65

5.6.5 Seed Number 65

5.6.6 Vehicle Red Interval for Intersections 1 and 2 65

5.6.7 Vehicle Green Interval for Intersections 1 and 2 66

5.6.8 Pedestrian Volume 66

5.6.9 Pedestrian WALK Interval 66

5.6.10 Pedestrian Clearance Period 66

5.6.11 Travel Times 67

5.6.12 Offset 67

5.6.13 Cycle Time 67

5.6.14 Minimum Vehicle Green Interval 67

5.6.15 Time-Space Diagram Output Parameters 68

5.6.16 Coordination 68

5.6.17 Output Options 68

6.0 MODEL TESTING 69

6.1 Model Development 69

6.2 Model Testing 69

7.0 DATA COLLECTION 78

7.1 Introduction 78

7.2 Data Collection Program 78

7.2.1 Locations 78

TABLE OF CONTENTS continued

Page

7.2.2 Methodology 81

87 Avenue 81

109 Street 84

7.2.3 Results and Analysis 84

7.3 Delay Surveys 85

8.0 COMPARISON OF FIELD AND MODEL DATA 88

8.1 Introduction 88

8.2 Model Input 88

8.2.1 87 Avenue Location 89

8.2.2 109 Street Location 89

8.3 Model Output 90

8.3.1 87 Avenue Location 90

8.3.2 109 Street Location 91

8.4 87 Avenue Location Comparison 92

8.4.1 114 Street and 87 Avenue 93

8.4.2 Mid-block Pedestrian Crossing 95

8.4.3 112 Street and 87 Avenue 101

8.5 109 Street Location Comparison 101

8.5.1 82 Avenue and 109 Street 103

8.5.2 University Avenue and 109 Street 103

8.5.3 76 Avenue and 109 Street 106

8.6 Analysis of Differences 111

Page
8.7 Summary 114

9.0 CONCLUSIONS 115
9.1 Conclusions 115
9.2 Additional Research 116
9.2.1 Pedestrian Characteristics 116
9.2.2 Program Enhancements 116
9.2.3 Statistical Analysis 117

LIST OF TABLES

Table		Page
6.1	Model Testing Input Data	70
8.1	Model Verification Input Data	89
8.2	87 Avenue Average Model Results	91
8.3	109 Street Average Model Results	92
8.4	87 Avenue Delay Comparison	92
8.5	109 Street Delay Comparison	101
8.6	Modelled, Observed and Modified Delays	111

LIST OF FIGURES

Figure		Page
1.1	Typical Pedestrian Signal Location	3
3.1	Negative Exponential Function	25
3.2	Shifted Negative Exponential Function	27
3.3	Erlang Distribution	29
3.4	Hyperlang Distribution	30
3.5	Overflow Delay and V/C Ratios	33
4.1	Coordination Time-Space Diagrams	41
4.2	Greenband and Throughband Coordination	44
4.3	Coordination TSDs with Sidestreet Traffic	46
4.4	Vehicle Inflow Distributions	47
5.1	General Program Flow Chart	50
5.2	Schematic Roadway Network	64
6.1	Vehicle Arrival and Departures Intersection #1 Large Scale	71
6.2	Vehicle Arrival and Departures Pedestrian Crossing Large Scale	73
6.3	Vehicle Arrival and Departures Intersection #2 Large Scale	74
6.4	Vehicle Arrival and Departures Intersection #1 Small Scale	75
6.5	Vehicle Arrival and Departures Pedestrian Crossing Small Scale	76
6.6	Vehicle Arrival and Departures Intersection #2 Small Scale	77
7.1	87 Avenue from 112 Street to 114 Street	79

LIST OF FIGURES continued

Figure | Page

7.2 109 Street from 76 Avenue to 82 Avenue 80

7.3 Signal Phasing Diagrams 82

7.4 Stopped and Overall Delay 87

8.1 Arrival Headway Probaility for 114 St and 87 Ave
Eastbound Through Movement (Intersection #1) 94

8.2 Modelled Vehicle Delay Probability
Intersection of 114 St and 87 Ave
Eastbound Through Movement (Intersection #1) 96

8.3 Modelled Pedestrian Delay Probability
87 Avenue Mid-Block Crossing 97

8.4 Modelled Pedestrian Group Size
87 Avenue Mid-Block Pedestrian Crossing 99

8.5 Modelled Vehicle Delay Probability
87 Ave Mid-Block Pedestrian Crossing
Eastbound Through Movement 100

8.6 Modelled Vehicle Delay Probability
Intersection of 112 St and 87 Ave
Eastbound Trhough Movement 102

8.7 Arrival Headway Probability for 82 Ave and 109 St
Southbound Through Movement (Intersection #1) 104

8.8 Modelled Vehicle Delay Probability
Intersection of 82 Ave and 109 St
Southbound Through Movement (Intersection #1) 105

8.9 Pedestrian Departure Group Size
109 Street Mid-Block Crossing 107

8.10 Modelled Pedestrian Delay Probability
109 Street Mid-Block Crossing 108

8.11 Modelled Vehicle Delay Probability
109 Street Mid-Block Crossing
Southbound Through Movement 109

LIST OF FIGURES **continued**

Figure **Page**

8.12 Modelled Vehicle Delay Probability
Intersection of 76 Ave and 109 St
Southbound Through Movement 110

8.13 Average Vehicle Delay
87 Avenue Network
Eastbound Through Movement 112

8.14 Average Vehicle Delay
109 Street Network
Southbound Through Movement 113

1.0 INTRODUCTION

Section 1.0 provides a brief overview of the thesis including the problem statement, the objective of the thesis, the scope of the research and the organization of the document.

1.1 MOTIVATION FOR RESEARCH

Within the City of Edmonton there are a number of signalized pedestrian crosswalks that are located at a variety of locations. Some of the signalized crosswalks are located within the Central Business District (CBD) and as such are fully integrated into the Area Traffic Control system (ATC). Other signal installations are located in areas that are under ATC but are not integrated into the ATC because of the relatively low pedestrian volumes or vehicle volumes. Still other installations have been integrated into and then removed from the ATC system because of problems caused by the lack of pedestrian signal responsiveness.

The decision to integrate a pedestrian signal into an area wide ATC is left to the discretion of the transportation engineer. Currently there are few guidelines to aid in the decision making process. This research was instituted to provide a basis for further investigation regarding the signalization and coordination of pedestrian activated traffic signals within a fixed-time traffic signal system.

1.2 PROBLEM STATEMENT

At the present time there are few quantitative tools and guidelines available to assist transportation engineers in making decisions regarding the coordination of pedestrian crossing signals with adjacent vehicle traffic signals. Current signal optimization programs do not allow for the inclusion of pedestrian crossing signals in a deterministic way. Those programs that do include pedestrian signals typically model them as fixed-time signals (e.g. TRANSYT) or as traffic actuated signals (e.g. NETSIM). A program is required that allows for random activations of a pedestrian signal that is located between two coordinated signals. The programmed model should quantify both pedestrian and vehicle delay. An example of the type of location at which a pedestrian signal is installed is shown in Figure 1.1.

1.3 THESIS OBJECTIVE

The primary objective of this thesis was to develop a computer simulation that would provide realistic estimates of the delay to both pedestrians and vehicles on a roadway that has a pedestrian activated traffic signal located between two fixed-time vehicle traffic signals.

To achieve this objective three main tasks were undertaken:

- develop a computer simulation model that incorporates random vehicle and pedestrian arrivals and that in turn generates output that measures delay to both pedestrians and vehicles
- collect field data
- verify the model with field data as necessary.

1.4 SCOPE OF THE RESEARCH

Initially the scope of the research was quite broad with the intent of developing guidelines for the coordination of pedestrians signals. As the project progressed it became evident that the scope would have to be narrowed substantially.

To investigate the operation of a pedestrian crossing requires in-depth study. The results of this additional research could then be incorporated into this project to develop a more refined model. This thesis should, therefore, be regarded as the first step towards developing a more detailed practical model of a signalized pedestrian crossing within a coordinated traffic signal system.

The scope of this thesis has been limited to the development of a computer program that models a pedestrian crossing that is located between two fixed-time traffic signals.

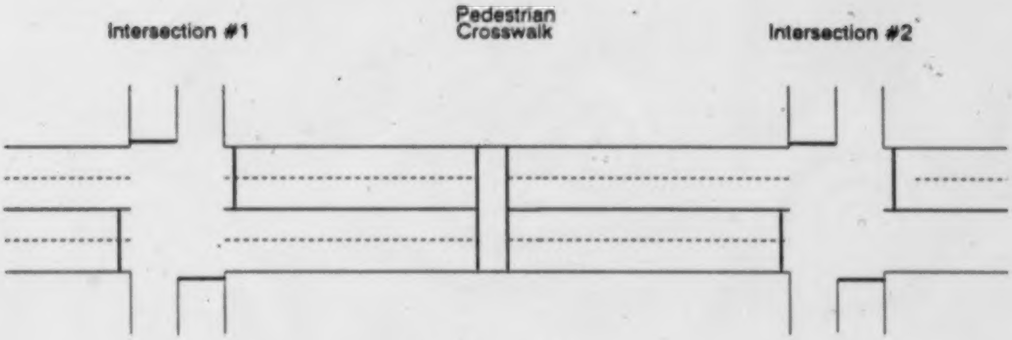

Intersection #1
Pedestrian Crosswalk
Intersection #2

FIGURE 1.1

TYPICAL PEDESTRIAN SIGNAL LOCATION

1.5 ORGANIZATION OF THESIS

This thesis is comprised of a total of nine chapters. Chapter 1 introduces the problem and identifies the thesis objective and the scope. Chapter 2 presents an overview of the results of the literature review while Chapter 3 provides the theoretical background to this research. Chapter 4 outlines the principles behind traffic operations and signal system design. Chapter 5 discusses the computer model in detail and Chapter 6 outlines the procedures used to develop and test the model. Chapter 7 provides information regarding the field data collection and Chapter 8 compares the field data to the model output. The final chapter, Chapter 9, puts forth the conclusions and recommendations of the research and identifies future research requirements. The Appendices contain a copy of the computer program source code and examples of the detailed program output.

2.0 LITERATURE REVIEW

Section 2.0 provides a discussion of the literature review and the various references used in this thesis.

2.1 OVERVIEW OF PAST RESEARCH EFFORTS

There is little literature available on the impact of pedestrian activated traffic signals on vehicle delay within a fixed-time traffic signal system within the North American context. One reason for the lack of research is the fact that pedestrian traffic signals are a relatively recent innovation although various simpler forms of pedestrian signal activation have existed since the 1930's. In Britain for example, the first pedestrian activated traffic signal or as it is known in Britain, a Pelican (**Pedestrian Light Controlled**), was installed in 1969. In Canada the first use of a pedestrian controlled signal occurred in the 1970's.

Simulation programs for isolated and coordinated pedestrian crossings, unsignalized and signalized, have been well researched[1,2,3] in the U.K. during the 1970's and 1980's.

2.2 PEDESTRIAN CROSSINGS

Before discussing the various research projects on pedestrian signals it is useful to illustrate where a pedestrian signal falls within the hierarchy of pedestrian crossing treatments. The Manual of Uniform Traffic Control Devices for Canada lists four pedestrian crosswalk categories as follows:

1) Side Mounted Signs;
    a) Pedestrian Crosswalk, and
    b) School Crosswalk

2) Special Crosswalk

3) Pedestrian Signals; and

4) Full Traffic Control Signals.

The unmarked pedestrian crossing that exists at every street corner should also be included as a fifth category.

Of the five types of pedestrian crossing, the pedestrian signal ranks as second from the top, i.e. one of the most sophisticated types of at-grade pedestrian crossing available. While the Manual does not provide regulations for the implementation of the various categories of pedestrian crosswalks, it does infer that traffic control signals are the exception rather than the rule. The Manual also stresses that before implementing a pedestrian crossing treatment, a detailed engineering study should be completed.

2.3 ISOLATED PEDESTRIAN SIGNAL

Griffiths et al.[1] conducted a major study into delays at pedestrian crossings between 1980 to 1984 at various locations throughout Britain. This study included an examination of Zebra, Fixed-Time and Vehicle-Actuated pedestrian crossing facilities. The three main objectives of the study were:

- "determination by direct measurement, of levels of pedestrian and vehicle delay and behaviour, together with details of site characteristics at a sample of free standing (isolated) Zebra, Fixed-Time Pelican and Vehicle Actuated Pelican Crossings;
- the evaluation of assumptions made in existing simulation models and the further development of these models using the survey data collected;
- the application of the simulation models of Zebra and Pelican crossings to provide simplified mathematical models for capacity and delay[1]."

The Zebra pedestrian crossing treatment consists of a series of wide parallel white lines that are painted on the roadway to delineate the pedestrian crossing. The fixed-time Pelican crossing is a pedestrian activated traffic signal that presents a red signal to drivers during the WALK phase and a flashing amber signal during the DON'T WALK clearance period. During the amber flash period, vehicles are permitted to move, slowly, through the crosswalk, provided there are no pedestrians in or about to enter the lane. The duration of the signal phases is preset.

The basic operation of the crossing for a vehicle-actuated Pelican crossing is the same as for a fixed-time crossing. The difference between the two types is that the vehicle-actuated has a minimum and maximum duration of the vehicle green phase. When a pedestrian pushes the button to enter a call to the controller, the controller checks for a suitable gap in vehicle traffic (using the vehicle detection system) before changing the vehicle signal indication to red and allowing the pedestrians to cross.

The project resulted in a number of observations and conclusions[1] regarding the various types of pedestrian crossing treatments.

- minimum pedestrian delay occurred at Zebra crossings
- as the pedestrian volume increased the pedestrian delay decreased (at Zebra crossings)
- minimum vehicle delay occurred at Pelican crossings
- pedestrian delay at Pelican crossings increased as vehicle volume increased between 400 - 1400 vph
- pedestrian arrival rate increased during the walk phase of the signal and decreased during the flashing don't walk and don't walk phases
- a significant number of pedestrian first arrivals at a Pelican do not press the signal activation button
- subsequent pedestrian arrivals only press the activation button after they themselves have been delayed.
- if vehicle flow was low or if it was platooned then pedestrians crossed the roadway against the signal during acceptable gaps

---

- the percentage of people that crossed during the Don't Walk phase of the signal seemed to depend on the following factors:
    - vehicle flow
    - distribution of vehicle headways
    - pedestrian flow
    - signal timing
    - pedestrian characteristics
    - roadway geometrics

During the study it was observed that pedestrian arrival rates exhibit a direct correlation to the pedestrian phase showing on the signal. It was expected that the pedestrian arrival rates would be purely random but pedestrians appeared to observe the signal and move more quickly to the crossing during the pedestrian WALK interval.

An equation was derived for the probability that the first pedestrian arrival would activate the signal. The derivation illustrated that a significant number of pedestrians did not activate the signal upon arrival. This may be attributed to pedestrians crossing during the DON'T WALK phase of the signal. Pedestrians arriving at the crossing will first evaluate the traffic flow to determine whether or not it is possible to cross the roadway without activating the signal. If sufficient gaps are present in the traffic stream the pedestrian will cross, or else activate the signal .

Upon completion of the [illegible] collection program and subsequent analysis, a set of computer programs was developed to model the Zebra, Fixed-Time and Vehicle Actuated pedestrian crossings. Incorporated into each of the models were mathematical formulae based on empirical observations. These formulae were designed to account for a number of specific characteristics of pedestrians as follows:

- pedestrian grouping including group size and frequency
- activation of the pedestrian signal
- variance in the pedestrian arrival patterns

- pedestrian adherence to traffic signals

The models yielded results that closely corresponded to field observations.

2.4 PEDESTRIAN CROSSING FACILITIES AND DELAY

In addition to the isolated pedestrian signals, research has been conducted into the effects of signalized pedestrian crossings on vehicle and pedestrian delay within a coordinated signal system[4,5]. In Britain, research was been conducted on Pelican signals which operate in a different manner from pedestrian crossing signals in North America. Nonetheless the conclusions reached when researching these pedestrian crossing facilities are relevant to the pedestrian crossings in North America.

In Britain, it is generally accepted that within an ATC system any Pelican installation must be tied into the ATC such that traffic interference is minimized. This methodology implies that pedestrian delay is not as important as vehicle delay. It has, however, been suggested[5] that pedestrian delay be weighted up to three times heavier than vehicle delay.

The British researchers conducted a before-and-after study of a single Pelican within an ATC system. Pedestrian and vehicle delay was measured before and after the Pelican was incorporated into the ATC. The survey indicated that more pedestrians crossed during the DONT WALK period when the signal was coordinated than when it was not. The average pedestrian delay increased sharply with coordination but the vehicle delay and queue length decreased.

2.5 PEDESTRIAN CROSSING FACILITIES WITHIN A LINKED SIGNAL SYSTEM

A simulation study was conducted in Britain in an attempt to quantify the effects of a pedestrian crossing within a linked signal system[5]. The two primary tools used in the evaluation were TRANSYT-8 and MULTSIM.

TRANSYT-8 is a traffic operations model that is used to design and evaluate traffic signal settings within a signalized roadway network. It employs average flow rates in short intervals representing the flow of traffic as cyclic flow profiles. The model was developed in Britain at the Transport Road Research Laboratory.

TRANSYT-8 was utilized to provide an approximate model of Pelican operation within a coordinated signal system. It was estimated that with pedestrian flows in excess of 100 pedestrians per hour, the Pelican would operate as a fixed-time signal. TRANSYT-8 was assumed to over-estimate the pedestrian delay because it treated the pedestrians as though they were vehicles complete with finite discharge rates and queuing. Unlike vehicles, pedestrians do not queue and can discharge simultaneously. This difficulty was partially overcome by specifying a Saturation Flow rate of 20,000 vehicles per hour (maximum allowed by TRANSYT). In addition, TRANSYT could not account for pedestrians crossing during acceptable gaps, regardless of the pedestrian signal phase.

To provide a comparison to the TRANSYT results, the program MULTSIM was used to evaluate the system. MULTSIM can more accurately model the behaviour of pedestrians and the operation of a Pelican crossing.

MULTSIM is a "microscopic model which allows the simulation of the flow of traffic in one direction along a stretch of roadway including up to six signal controlled intersections.[5]" The vehicle-by-vehicle simulation program includes a facility to model Pelican crossings. Pedestrian behaviour was modelled to account for gap acceptance regardless of the pedestrian signal indication but did not account for pedestrian grouping. One limitation of MULTSIM is that it considers one-way roadways only.

After simulating the operation of the Pelican crossing using both MULTSIM and TRANSYT, it was concluded that during peak periods a number of short pedestrian WALK intervals would be the most effective, while longer WALK intervals would be suitable for off-peak periods. The more frequent short pedestrian WALK intervals would help to minimize pedestrian delay as well as minimizing pedestrian disobedience of the signal. During the off-peak periods the WALK interval could be lengthened because there would be fewer pedestrians and fewer vehicles. With fewer vehicles the number of acceptable gaps would increase and pedestrian safety would not be compromised even if pedestrians crossed against the signal.

TRANSYT was used to determine the optimum signal settings for the Pelican for various locations of the Pelican between the two signalized intersections. A component of the research included the determination of the optimum location of the Pelican in terms of minimizing overall system delay. For one-way roadways the optimum Pelican location was as close to the upstream signal as possible but for two-way roadways the optimum location was found to be at the mid-point between the upstream and downstream traffic signals.

When MULTSIM was used to model the Pelican crossings it was found that as the distance between the upstream signal and the Pelican increased, the number of pedestrians crossing on the WALK interval also increased. The researchers concluded that the average accepted gap (i.e. the degree to which pedestrians would disobey the signal) would follow a log-normal distribution with a site specific mean value[5]. This increase in pedestrian adherence to the signal was attributed to the dispersion of the vehicle platoon which resulted in fewer gaps for the pedestrians to utilize when crossing the roadway.

MULTSIM was used to compare the network operation with and without the inclusion of the Pelican in the signal coordination. It was discovered that, as predicted, when the Pelican is coordinated with the vehicle signals, the pedestrian delay increases while the vehicle delay decreases. With coordination of the Pelican, the adherence of pedestrians to the indicated signal was higher than for uncoordinated. This was attributed to the fact that with coordination, the Pelican WALK interval coincided with the largest and maximum number of gaps in the traffic stream.

The MULTSIM model runs also yielded that if the Pelican is located more than 300 - 400 metres downstream from the vehicle signal there is little benefit to including the Pelican in the signal coordination. In Great Britain for distances greater than 300 - 400 metres, traffic is no longer adequately platooned to facilitate signal coordination. In other locales this distance is greater; in

Edmonton traffic signals have been effectively coordinated at distances in excess of 800 metres.

The observations that resulted from conducting a number of MULTSIM and TRANSYT runs included:

- vehicle travel time is linearly proportional to vehicle volume
- vehicle delay was the highest when the Pelican was double cycled with short pedestrian WALK intervals as opposed to single cycle with a double duration WALK interval.
- vehicle delay rises slowly in relation to pedestrian volume
- increasing the length of the pedestrian WALK interval produced only marginal reductions in the pedestrian delay
- for pedestrians, two short WALK intervals results in less delay than one long WALK interval.
- the crossing behaviour of pedestrians is more closely related to safety than to delay.
- the percentage of pedestrians crossing during the WALK interval increases as the vehicle volume increases.
- short Pelican cycle times results in higher pedestrian adherence to the signal
- in the MULTSIM program, pedestrian delays are highly dependent on the gap acceptance function used.
- if a Pelican is included in the signal coordination scheme, the vehicle delay decreases but the pedestrian delay increases.
- for a realistic estimation of the performance of the network, pedestrian delay should have a weighting of 3.0 relative to the vehicle delay.

- the increase in vehicle delay caused by the introduction of a pedestrian crossing signal is outweighed by the decrease in the delay to pedestrians.

It should be noted that the above conclusions are based on a number of program runs and not on empirical data.

2.6 PEDESTRIAN ON-LINE OPERATION DETERMINATION

The City of Edmonton Transportation Department has established a set of guidelines to assist the transportation engineer in determining whether or not a pedestrian traffic signal should be included in the ATC[6]. The guidelines are based on empirical and theoretical methods. A total of five parameters are used in the evaluation:

a) major road traffic volume;

b) effectiveness of coordination of the pedestrian /bus-pedestrian signal and adjacent system signals;

c) the arrival pattern of pedestrians or buses at the signal

d) type of actuation, bus or pedestrian; and,

e) route coordination: the conformity of the operating mode of the signals along the route.

The parameters are utilized to determine the "online/offline index" (OOI) which is a weighted average of the parameters as follows:

$$OOI = 2a + 3b + 2c + d + 3e$$

For each of the parameters an index is determined for use in the OOI.

2.6.1 Major Road Traffic Volume Index

The major road traffic volume index is determined using a probabilistic model based on the negative exponential headway distribution. Using the negative exponential headway distribution a threshold volume is determined for the roadway which is in turn compared to the actual roadway volume to calculate the index.

The threshold volume has been defined as being the major street traffic volume that will cause pedestrians (or bus drivers) tolerate the additional delay imposed when waiting for a traffic signal. The determination of the threshold volume is based on the 85th percentile probability of a gap of a given size occurring.

2.6.2 Effectiveness of Coordination Index

This index is determined from the nomograph presented in the Manual of Uniform Traffic Control Devices for Canada. The value of the index is based on the distance between the signals, the signal cycle time and the operational speed of the roadway.

2.6.3 Arrival Pattern Index

The arrival pattern of the pedestrians and/or buses is used to calculate this index. Based on field counts, the actual number of signal activations per hour is determined. The ratio of actual activations to maximum number of activations is the arrival pattern index.

2.6.4 Bus/Pedestrian Index

This index is more subjective in nature and has been set as follows:

= -1 if ≥ 4 bus activations in the peak hour

= 0 if < 4 bus activations in the peak hour

= 1 if it is a pedestrian call

The values of the index indicate that the greatest weight is given to pedestrian activations

2.6.5 Route Coordination Index

The value of this index is -1 if the route is non-coordinated (adjacent signals are off-line) and +1 if the route is coordinated (adjacent signals are On-line).

2.6.6 Summary

The online/offline evaluation index as set out by the City of Edmonton is comprised of empirical and theoretical components as well as specific subjective cut-off points for certain indices. The index is an attempt to provide a quantifiable measure that can be used to determine the effectiveness of including the signal in the ATC. If the index is positive, the signal should be coordinated, negative and the signal should not be coordinated.

2.7 ISOLATED INTERSECTION PEDESTRIAN CALCULATIONS

Whenever the signal timing for a signalized intersection is being designed or analyzed, a key component is the pedestrian. It is critical that pedestrians be provided with sufficient time to cross the roadway(s) without compromising their safety. To this end the Canadian Capacity Guide for Signalized Intersections[7] (CCGSI) and the Manual on Uniform Traffic Control Devices[8] (MUTCD) provide detailed discussions of pedestrian walk intervals and clearance periods. The Highway Capacity Manual[9] (HCM) does not provide a detailed discussion of pedestrian requirements for signalized intersections but instead provides methods for calculating pedestrian capacities for corner crosswalks and pedestrian walkways.

The minimum WALK interval is defined as "a minimum duration of a "walk" signal display during which the group of pedestrians who were waiting for this display can reach a reasonable distance in the crosswalk at a comfortable speed[6]." The clearance period is defined as "the time required for the pedestrian who entered the crosswalk at the very end of the walk interval to reach a safe refuge, either at the opposite sidewalk or the central island, at a comfortable speed before a conflicting vehicle green commences[6]."

The minimum walk interval suggested is 7 seconds[6,7,8] to allow pedestrians to proceed into the crosswalk before the clearance interval begins. The seven second minimum is referred to indirectly in the HCM within the minimum green interval calculation for a specific phase. The MUTCD and CCGSI both refer to the minimum WALK interval directly and suggest that, if necessary, to accommodate the pedestrian demand, the WALK interval should be lengthened.

The pedestrian clearance interval is calculated by dividing the walk distance, i.e. the width of the crosswalk typically taken as face-of-curb to face-of-curb distance, by the average pedestrian walking speed, typically 1.2 metres/second. The clearance interval is indicated via the flashing DON'T WALK pedestrian signal.

Neither the CCGSI or HCM provides for pedestrian delay calculation in its analysis of a signalized intersection. The HCM does provide an entire chapter that covers the basic principles of pedestrian flow as well as providing procedures for the analysis of pedestrian facilities. When determining the Level of Service (LOS) of a signalized intersection, however, no consideration is given to pedestrian delay.

The lack of consideration regarding pedestrians at signalized intersections is consistent with the philosophy behind the HCM and the CCGSI. The CCGSI is intended as a guide for design and analysis to determine the optimum signal timing plan based on minimizing the impact of the signal on vehicle traffic. The HCM is designed for use in signal analysis rather than design. Both publications offer the perspective of the motor vehicle only rather than that of the motor vehicle and pedestrian.

2.8 PEDESTRIAN DELAY AT SIGNALIZED INTERSECTIONS

2.8.1 Australia

Research in Australia has yielded formulae to calculate pedestrian delays, stops and queues based on the signal cycle and red interval. These formulae have been incorporated into the manual used in determining signal capacity and timing analysis for Australia[10]. They were derived based on the assumption that for pedestrian movements there would be no overflow queues and zero flow ratios.

These assumptions are rationalized based on the fact that very rarely are pedestrians unable to cross due to high pedestrian volumes, i.e. pedestrians do not queue in the same manner as vehicles nor do they follow the same rules for queue discharge as do vehicles. The flow ratio, y, can be assumed to be zero because the pedestrian saturation flow rate is very high, particularly when compared to vehicle saturation flow rates.

The equation for average pedestrian delay is given as:

$$d = r^2/2c \qquad \text{Eqn. 2.1}$$

where: r = effective red interval (including clearance interval) in seconds

c = cycle time in seconds

This is a direct derivation from the equation for average individual delay, as derived from queuing theory given (described for instance in Reference 14) as follows:

$$d = r^2/2c(1-y) \qquad \text{Eqn. 2.2}$$

Letting y approach zero in Eqn. 2.2 yields equation 2.1.

The equation for the number of pedestrians stopped at a traffic signal is given as:

$$H = qr/c \qquad \text{Eqn. 2.3}$$

where: q = pedestrian arrival rate

H = same units as q

r = effective red interval (including clearance interval) in seconds

c = cycle time in seconds

As well the equation for the number of queued pedestrians at the start of the WALK interval is given as:

$$N = qr \qquad \text{Eqn. 2.4}$$

where: q = pedestrian arrival rate in pedestrians per second r = effective red interval (including clearance interval) in seconds

N = is the number of pedestrians

Equations 2.3 and 2.4 assumed that no pedestrians are stopped during the WALK interval, i.e. the pedestrian queues dissipate instantly and there is no overflow queue[10].

The above equations can be used for either design or analysis but it is implied that the primary focus is the motor vehicle and not the pedestrian.

2.8.2 Highway Capacity Manual

The HCM provides a chapter on the analysis of crosswalks at a street corner or for a walkway but not for mid-block crossings. The analysis provides estimates of the available pedestrian space and the pedestrian Level of Service (LOS). The signal timing plan, the pedestrian volumes and the corner geometrics are all used in the analysis. The analysis does not definitively determine pedestrian delay and or vehicle delay at the intersection, simultaneously.

2.9 TRANSPORTATION MODELS AND PEDESTRIANS

There are a number of different transportation progrmas being used to determine the optimum traffic signal settings for roadway networks. There is a hierarchy of models used in the determination and evaluation of signal timing plans. At a low level there are models that simulate the operation of single intersections as though they were isolated from all external influences while at the top level there are models that consider a network of traffic signals, determining the overall level of service of the network.

The network level models include such programs as NETSIM, TRANSYT, and CONTRAM. Each of these programs is discussed in the following sections.

2.9.1 NETSIM

NETSIM (NETwork SImulation Model) is a model that is based on the microscopic simulation of individual vehicle trajectories as they move through a street network."[11] The model was designed to be able to test different traffic control strategies under heavy traffic flow conditions. The model has been revised and updated since it was first released in 1980 and is now called TRAF-NETSIM. The revised version was unavailable at the time at which the research commenced.

NETSIM does have the capacity to model pedestrian phases for a signalized intersection but is not capable of simulating a mid-block pedestrian signal. The model uses a pedestrian actuation to override a specific vehicle phase. At a mid-block signal there is no vehicle phase to override because there is only one vehicle phase which conflicts with the pedestrian phase.

NETSIM was used to analyze the effects of a mid-block pedestrian crossing by modifying the data input[12]. Pedestrians were simulated as four foot long trucks travelling at four feet per second. Due to insufficient time and funding it was not possible for the researchers to perform a detailed analysis of the results. Based on initial results it was concluded that this methodology could be feasible. From an analytical standpoint, the modelling of pedestrians as short trucks is undesirable.

Subsequent to the research using pedestrians modelled as four-foot long trucks, the model was modified to accommodate pedestrian activations at a signalized intersection. With this modification an attempt was made to simulate a randomly activated mid-block pedestrian signal using NETSIM. The modification was, however, designed to accommodate pedestrian activations at a multiphase vehicle traffic signal rather than a single phase vehicle traffic signal such as a mid-block pedestrian crossing. Various methods of modifying the input data set were unsuccessfully used in an attempt to simulate a mid-block crossing.

2.9.2 TRANSYT

The TRANSYT (TRAffic Network StudY Tool) model has two primary functions: to simulate the flow of traffic in a signalized network; and, to develop optimized traffic signal timing plans[13]. The model optimizes the traffic signal timings based on a specified base cycle time with the user specifying the phases and the phase sequence. The model does not make provisions for pedestrian crosswalks except for allowing an exclusive pedestrian phase for a four legged intersection, i.e. a scramble phase.

2.9.3 CONTRAM

The CONTRAM (CONtinuous TRaffic Assignment Model) model is a "traffic assignment model for the use in the design of traffic management schemes"[14]. The model has been designed to account for the time-varying nature of (vehicle) traffic in a network and the model assigns traffic to the network in "packets" or groups of vehicles. The model focuses on the assessment of vehicle traffic operations and does not have any facility for the input of pedestrian volumes or pedestrian crosswalks.

2.9.4 Summary

The three traffic operations models discussed work from the same paradigm: optimize the operation of the signalized roadway networks to minimize the disutility to vehicles. This inherent bias towards vehicles makes these models unsuitable for the modelling of pedestrian signal operations, even if a methodology could be devised to allow the models to represent pedestrians.

2.10 COORDINATION

The HCM chapter on signalized intersections lists five arrival types for dominant arrival flow at an intersection approach. It also states that "this is a general categorization that attempts to approximately quantify the quality of progression on the approach"[9]. Alternatively stated it is an attempt to quantify the quality of the signal coordination.

The five arrival types are:

- Type 1 - This condition is defined as a dense platoon arriving at the intersection at the beginning of the red phase. This is the worst platoon condition.
- Type 2 - This condition may be a dense platoon arriving during the middle of the red phase or a dispersed platoon arriving throughout the red phase. Better than Type 1, this is still an unfavourable platoon condition.

- **Type 3** - This condition represents totally random arrivals. This occurs when arrivals are widely dispersed throughout the red and green phases, and/or where the approach is totally uncoördinated with other signals - either because it is at an isolated location or because nearby signals operate on different cycle lengths. This is an average condition.

- **Type 4** - This condition is defined as a dense platoon arriving during the middle of the green phase, or a dispersed platoon arriving throughout the green phase. This is a moderately favourable platoon condition.

- **Type 5** - This condition is defined as a dense platoon arriving at the beginning of the green phase. It is the most favourable platoon condition.

The HCM has an empirical, but inexact, method of determining the arrival type. The manual recommends that the arrival type be determined as accurately as possible because it is used in the determination of level-of-service and delay estimation for an intersection.

Although the HCM chapter on signalized intersections is predominantly concerned with the analysis of the operation of single intersections, the use of the arrival types does acknowledge the impact of other traffic control devices on the intersection. In other words, the use of the five arrival 'types' is a concession to the impact of traffic signal coordination. These arrival types also indicate that traffic signal coordination is a desirable characteristic of a signalized roadway network.

2.11 SUMMARY

The discussions above illustrate the bias of existing traffic modelling programs towards the motor vehicle. Various manuals and guides include discussions regarding the impact of pedestrians on traffic signal timings, the capacity of walkways and the impact of traffic signals on pedestrians. An attempt was made in Utah to assess pedestrian crossing using existing models but the results of this research were not finalized[12]. There are, however, no comprehensive methods or models by which to assess the impact of signalized pedestrian crosswalks on both pedestrians and vehicles.

The literature search was conducted using on-line search techniques that utilize computers to access large databases of engineering abstracts. In addition, the University of Alberta and Stanley Associates Engineering libraries were searched for relevant materials.

3.0 THEORETICAL BACKGROUND

Section 3.0 provides a detailed theoretical background to the work presented in this thesis. Specifically, it addresses the headway distribution that was used for vehicles and pedestrians, the type of delay presented, pedestrian behaviour and where the delay is accumulated

3.1 INTRODUCTION

In order to develop a realistic model, the situations to be modelled were clearly outlined in order to define which variables should be included in the model and which variables could be discounted. The data that was to be input into the model to ensure valid model output was also a key consideration. As part of this process three key theoretical model components were identified: Headway Distribution, Delay and Pedestrian Behaviour. These components are discussed in this section.

3.2 HEADWAY DISTRIBUTION

3.2.1 Probabilistic versus Deterministic Arrival Patterns

When attempting to describe (or model) vehicle behaviour at an intersection, it is useful to do so with a minimal quantity of field data. As a result, considerable research has been conducted into describing vehicle arrival patterns in terms of statistical distributions.

In a pure sense, vehicles arriving at an intersection will arrive in a random pattern (probabilistically) and as such can be described by a statistical distribution. If there is some type of traffic control device, upstream of the measurement location that impacts the vehicle arrival distribution, the arrival pattern can still be described by a statistical means but now has a deterministic component, i.e. cyclic flow profiles.

For the purposes of this exercise, the arrival pattern at the first signalized intersection is assumed to be random and at the pedestrian crossing and the second intersection, deterministic.

3.2.2 Types of Distributions

There are two basic types of statistical distributions used in transportation modelling: counting and interval. Counting distributions are used to describe the occurrence of things that can be counted, such as vehicles in a traffic stream. Interval distributions are used to describe the occurrence of the time intervals between events[15].

To determine the vehicle arrival or headway distribution an interval distribution is used.

There are a number of different types of interval distributions that have been used in the past to represent traffic streams, including the negative exponential, the shifted negative exponential, the Erlang and the Hyperlang. Each of the distributions is briefly described below.

Negative Exponential Distribution

The negative exponential distribution is considered to be an "elementary" interval distribution that is derived directly from the Poisson Counting Distribution. The equation for the negative exponential distribution has the form:

$$P(h \geq t) = e^{-Vt/3600}$$

Where: $P(h \geq t)$ = the probability of a headway being greater than or equal to some time t

t = time in seconds

h = headway in seconds

V = hourly traffic volume

This equation can be simplified by substituting $T = 3600/V$, yielding:

$$P(h \geq t) = e^{-t/T}$$

The negative exponential function is illustrated in Figure 3.1 for various values of T.

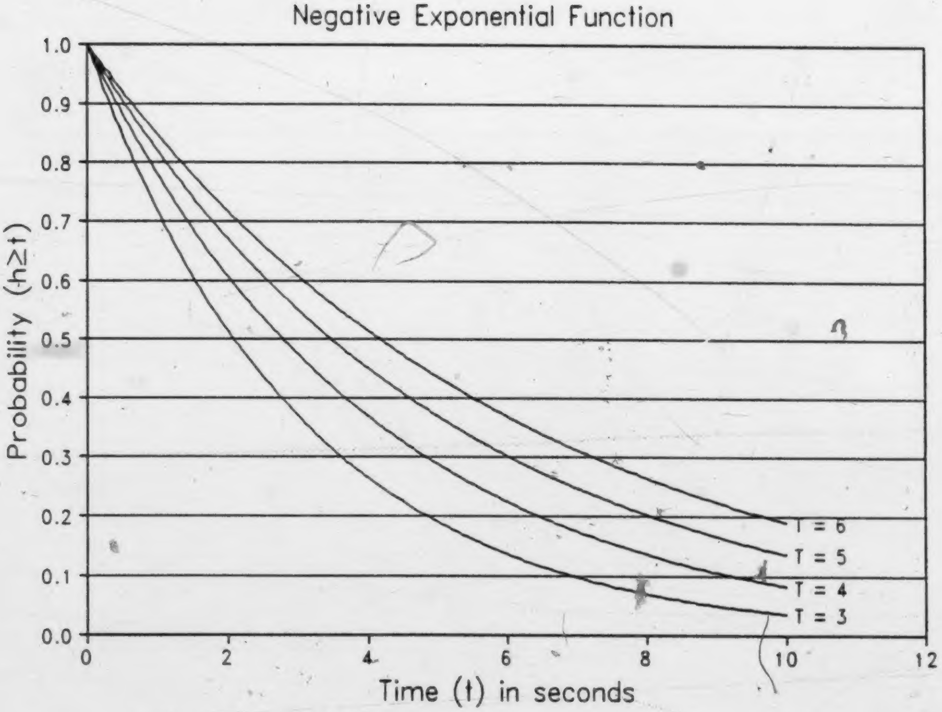


FIGURE 3.1

NEGATIVE EXPONENTIAL FUNCTION

This equation is based on the assumption of conditions of random traffic flow implying that the volume is low. The negative exponential distribution includes very small headways, approaching $t=0$.

Because this distribution predicts very small headways, it is unsuitable for single lane approaches where finite vehicle length and finite vehicle spacing preclude headways of $t=0$. In cases of multiple lanes it is, however, possible to observe $t=0$ headways (i.e. the vehicles arrive simultaneously).

Shifted Negative Exponential Distribution

The shifted exponential distribution is almost identical to the negative exponential distribution except, as the name implies, that it is shifted to the right. The equation for this distribution is as follows:

$$P(h \geq t) = e^{-(t-\tau)/(T-\tau)}$$

Where: τ - minimum allowable headway (seconds)
and for $t < \tau$, $P(h \geq t) = 1.0$

The shifted negative exponential function is illustrated in Figure 3.2 for various values of T.

The advantage of the shifted negative exponential distribution is that it does not allow headways less than the minimum specified using τ. This minimum allowable headway is advantageous when modelling a single lane of traffic flow. In such cases the value of τ can be calculated by dividing 3600 (seconds per hour) by the measured value of the average saturation flow for the surveyed lane. This will yield a value of τ, the minimum headway, in seconds.

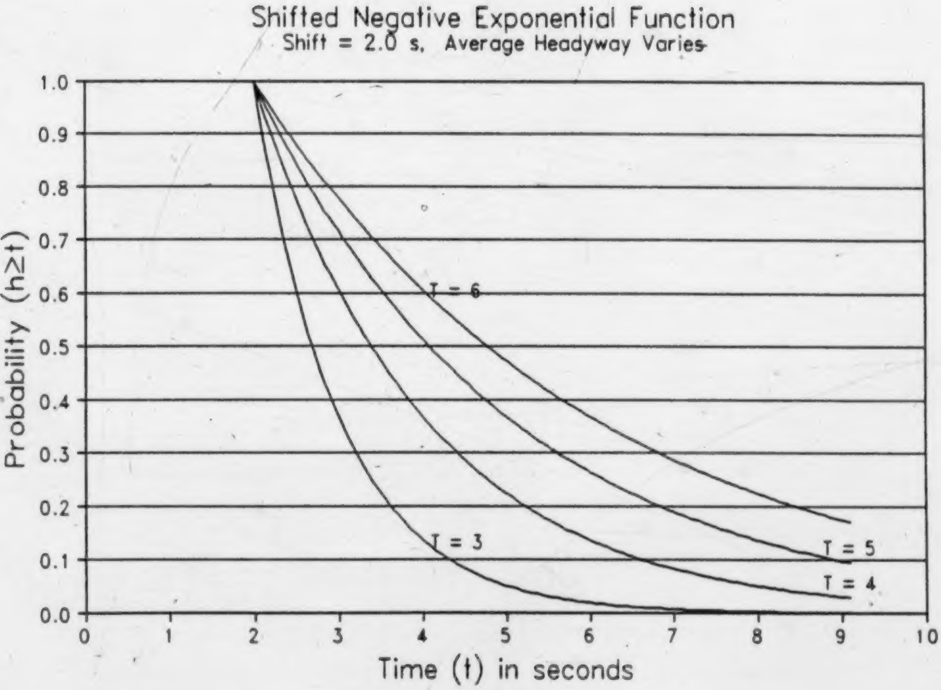


FIGURE 3.2

SHIFTED NEGATIVE EXPONENTIAL FUNCTION

Erlang Distribution

The Erlang distribution is also a distribution that is related to the generalized Poisson distribution in the same manner that the negative exponential distribution is related to the Poisson counting distribution. The Erlang distribution allows for small headways with a very low but not zero probability.

The Erlang distribution has the general form:

$$P(h \geq t) = \Sigma\, (\text{[illegible]}/T)^i\, [(e^{-(kt)/T})/i!]$$

The graph of the Erlang Distribution is illustrated in Figure 3.3.

The Erlang distribution is particularly useful for multi-lane situations where small headways are possible. The difference between the Erlang and shifted negative exponential distribution is that the Erlang does not preclude small headways.

Hyperlang Distribution

The hyperlang (or hyper-Erlang) distribution is one of the family of models known as 'Composite Headway Models'. Composite headway models assume that any traffic stream is composed of two sub-sets of vehicles: one set free-flowing and the other set constrained by surrounding vehicles. This assumption in turn yields a model that is comprised of two components, one describing the portion of the vehicle stream that is unconstrained and the other component describing those vehicles that are constrained.

The two components of the hyperlang model are the shifted negative exponential function and the Erlang function. The shifted negative exponential function is used to describe the behaviour of the unconstrained or free flowing vehicles and the Erlang function is used to describe the headways for the constrained vehicles. The Erlang function is used for the constrained vehicles because the constrained vehicles arrive in a non-random pattern which is easily simulated using the Erlang function.

A numerical example of the hyperlang function worked out by Dawson et al[16], using data from the 1965 Highway Capacity Manual is illustrated in Figure 3.4.

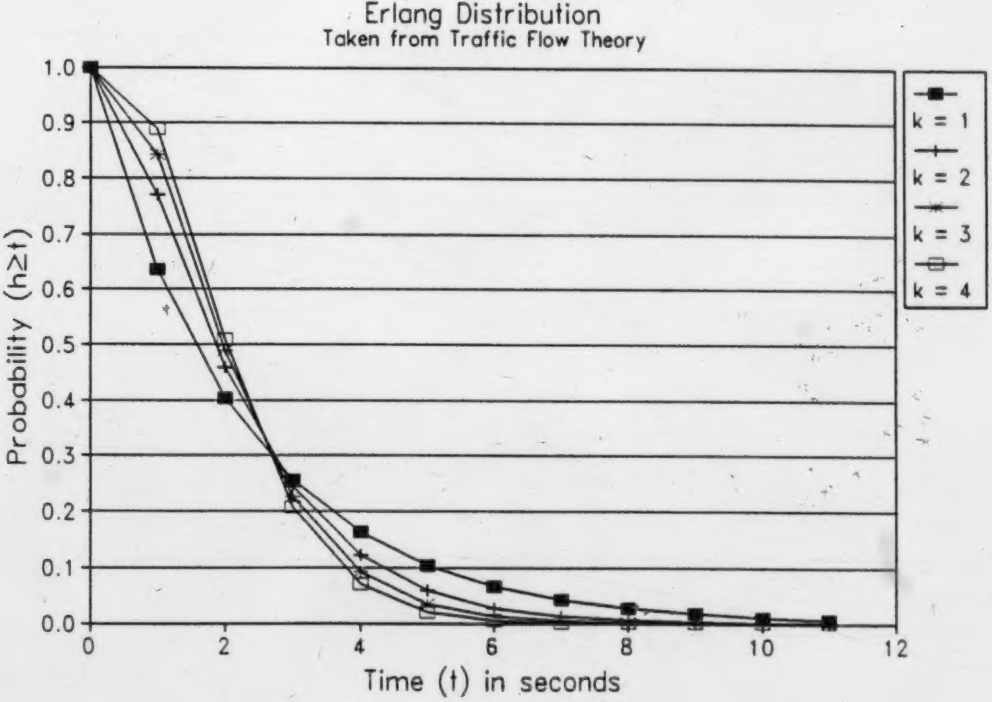


FIGURE 3.3

ERLANG DISTRIBUTION

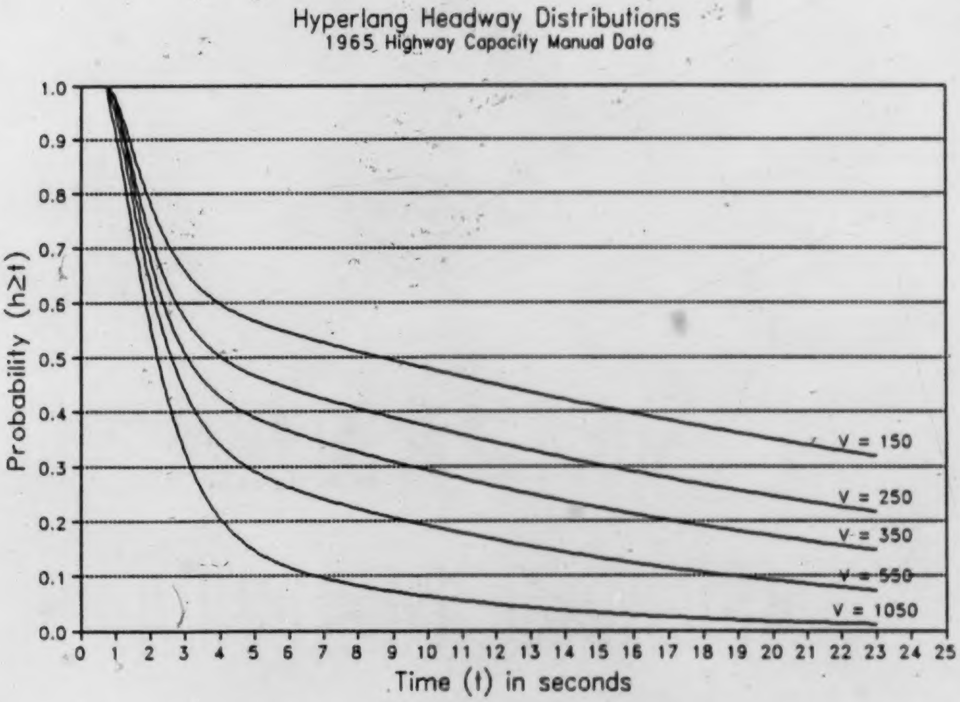


FIGURE 3.4

HYPERLANG DISTRIBUTION

The hyperlang function has the form:

$$P(h \geq t) = \alpha_1 e^{-(t-\tau)/(T-\tau)} + \alpha_2 \Sigma \, (kt/T)^i \, [(e^{-(kt)/T})/i!]$$

where: α_1 = proportion of free flowing vehicles in the traffic stream

α_2 = $(1-\alpha_1)$, the proportion of constrained vehicles in the traffic stream

The hyperlang distribution shows a good correspondence to actual headway distributions as measured in the field.

Summary

As illustrated by the discussion, there are a number of statistical distributions that can be used to describe traffic flow headways. Each distribution has advantages and disadvantages. The exponential functions require minimal input data and computation while providing adequate correspondence to observed data, particularly for low volume situations. Conversely, the Erlang and hyperlang distributions require more input data and computational effort but provide a better correspondence to observed data, over a wider range of traffic volumes.

The shifted negative exponential function is suitable for modelling headway distributions when the objective is to determine delay. If the objective of the model is to determine gaps for the purposes of gap acceptance/rejection by pedestrians wishing to cross the traffic stream then a more accurate distribution such as the hyperlang distribution should be used[16].

3.3 DELAY

3.3.1 Uniform and Overflow Delay

According to the Canadian Capacity Guide for Signalized Intersections[7], delay for individual lanes and for the overall intersection represents the most powerful means of evaluating intersection performance and provides a method of comparing intersection operations.

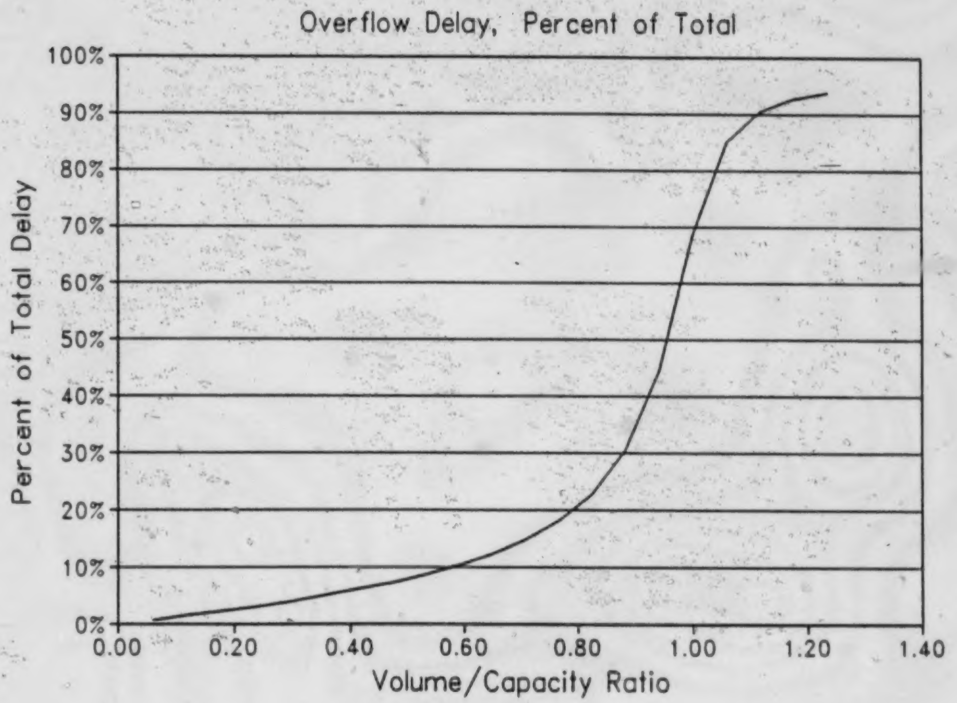
There are two principal types of delay: Uniform Delay and Overflow Delay. Uniform delay is the delay caused by the interruption of traffic flow by a traffic signal and is a function of the Volume to Capacity ratio (V/C) and the signal cycle time. Overflow delay, as its name implies, is the delay caused when all of the queued vehicles are not able to discharge within one signal cycle.

Overflow delay is dependent on the magnitude of the V/C ratio. When the traffic volume is low, overflow delay will occur randomly, but if the volume is high (relative to the capacity) the overflow delay will be continuous, forming a significant component of the total delay. As illustrated in Figure 3.5, for low V/C ratios, (less than 0.80) the overflow delay comprises less than 20 percent of the total delay, but as the V/C ratio increases over 0.80, its percentage of the total delay increases rapidly.

In conditions where the network is saturated or over-saturated it is not possible to have coordination because the vehicle queues are growing. All of the queued vehicles are unable to discharge during a given cycle and therefore coordination is not achieved.

3.3.2 Delay Measurement

There are a number of ways in which it is possible to measure delay including: a Time-Space Diagram and a Queuing Diagram. The Time-Space Diagram method utilizes electronic means to record the arrival and departure times of vehicles at a signal. The Queuing Diagram method utilizes field counts of queues at a signal. For the queue count there are a number of different methods in which different points within the signal cycle are used for counting the queued vehicles.



THESDELAY.WKQ

FIGURE 3.5

OVERFLOW DELAY AND V/C RATIOS

When using delay as an evaluation tool, it is difficult to determine in the field. Teply[17] has shown that the usual delay surveys underestimate delay and that different delay survey methods based on queue counts do not yield identical results because of the different assumptions in the application of queuing theory. In addition, Teply has shown that delay surveys based on stopped queue counts may overestimate stopped delay to the point of exceeding overall delay values. He has concluded that delay is a valid engineering tool provided that it is properly calculated and that the limitations of a particular survey/analytical method are acknowledged.

Teply developed two equations that may be used to relate stopped delay to overall delay. The first equation is based on the duration of the red interval and on deceleration delay.

$$D/D_s = r^2/(r-t_d)^2 \qquad \text{Equation 3.1}$$

where: D = overall delay

D_s = stopped delay

r = duration of red interval (seconds)

t_d = deceleration delay (seconds)

The second equation is based on the arrival rate and saturation flow rate as given below in Equation 3.2:

$$D/D_c = 1/(1-y^2) \qquad \text{Equation 3.2}$$

where: D = overall delay

D_c = calculated delay

$y = q/s$

As pointed out by Teply, equations 3.1 and 3.2 represent extreme cases and in most cases the ratio of overall delay to stopped delay is dependent on the red interval as well as on the arrival and saturation flows.

3.4 PEDESTRIAN BEHAVIOUR

Pedestrian behaviour is difficult to accurately predict and therefore difficult to model. Pedestrian behaviour can vary according to age group, traffic volume, location and many other factors. General observations can be made regarding specific groups of pedestrians but for specific modelling purposes it is necessary to collect field data.

A number of different pedestrian characteristics are discussed below.

3.4.1 Signal Obeyance

The degree to which pedestrians obey traffic signals is dependant on a number of factors including pedestrian age, roadway traffic volume, climate and roadway width. Very young pedestrians, i.e. under 10 years old or older pedestrians (above 55 years) generally tend to strictly obey traffic signals. Young pedestrians obey the signals because of ingrained concepts regarding traffic and traffic signals as taught by parents. Older pedestrians obey the signals for a number of reasons including not being able to walk as quickly as they once did.

Roadway traffic volume plays a key role in the degree to which pedestrians obey the traffic signal[1]. If, for example, traffic volumes are heavy there will be few gap opportunities, outside of those created by the signal, for pedestrians to utilize. Conversely, if traffic volumes are low, the frequency of acceptable gaps will increase, thereby allowing pedestrians to cross, regardless of the signal indication.

A related consideration is the degree of platooning of the traffic. If the traffic volume is high and is well platooned, acceptable gaps may be present between platoons thereby allowing pedestrians to cross. Conversely, traffic volume could be low and the platoons highly dispersed thereby eliminating most of the acceptable gaps. Therefore, when attempting to ascertain in advance the degree to which pedestrians will obey traffic signals, it is important not only to consider traffic volume but also platooning.

3.4.2 Signal Activation

In the case of activated pedestrian signals, it is the responsibility of the pedestrian to activate the signal. Griffiths et al. found that at some locations the percentage of pedestrians activating the signal was as low as 50 percent[1]. It was discovered that the percentage of activations correlated to the vehicle volume and the degree to which the vehicles were platooned. If the volume was low or if the vehicles were platooned pedestrians would cross against the signal without activating it.

Upon arrival at the crosswalk, pedestrians would first evaluate the vehicle traffic stream to determine the need for activating the signal. If the pedestrian judged that it was possible to cross without the assistance of the signal then the pedestrian would not activate the signal and proceed to wait for an acceptable gap. Subsequent pedestrian arrivals would only activate the signal if they themselves were delayed[6]. The activation of the pedestrian signal is a subjective decision on the part of the pedestrian.

3.4.3 Grouping

Another important facet of pedestrian behaviour is the grouping of pedestrian arrivals. It was observed that pedestrians travel in groups ranging in size from 1 to 5 people (typically). Since pedestrians arrive in groups there will be only one signal activation per group of pedestrians and all pedestrians in the group will experience the same delay. In addition, pedestrians may arrive singly forming a group or queue at the signal with all pedestrians utilizing the same WALK interval, in which case the magnitude of delay will depend on the arrival time.

3.4.4 Climate/Weather

When considering the behaviour of pedestrians it is important to consider the climate in which pedestrians must wait for a WALK phase. When the weather is inclement, pedestrians are unwilling to wait too long at a crosswalk. Vehicle drivers and passengers are protected from the elements and are therefore not as effected by the climate as are pedestrians. While the relative exposure to the elements is a subjective measurement, it is nonetheless an important consideration when assessing the behaviour of pedestrians, particularly over the course of a one year period or when observing differences from one location to another.

3.4.5 Delay

Pedestrians appear to be more sensitive to delay than are auto drivers. If an auto driver is frustrated with an imposed delay the drivers only recourse would be to divert to another, less delayed, route. Attempting to advance through a red signal is not usually a viable option for automobiles. Contrary to that, pedestrians, in North America, that experience what is perceived to be unacceptable delay, can and will cross against the traffic signal forcing vehicle traffic to yield the right-of-way .

It may be illegal for the pedestrian to cross the street against the signal, but if an opportunity is presented, the pedestrian may cross, particularly if they have been waiting too long for the signal to change. Pedestrian violations are more prevalent at mid-block pedestrian signals when compared to signalized intersections. At a mid-block location the pedestrian need only contend with two directional traffic flow whereas at a signalized intersection multi-directional traffic flows must be considered.

Research conducted in Britain has examined the impacts of a pedestrian crosswalk with a single cycle with, for example, a 20 second WALK interval, as opposed to two cycles each with a 10 second WALK interval[7]. The results indicated that the pedestrian adherence to the signal would be much higher for the double cycled signal. This is intuitively logical because with the double cycled signal pedestrians are presented with twice as many opportunities to cross with half of the delay of the single cycled crosswalk. Pedestrians, unlike vehicles, discharge simultaneously and are therefore relatively unaffected by the length of the WALK interval. For this reason, a 20 second WALK interval does not discharge twice as many pedestrians as a 10 second WALK interval, unless the pedestrian volume is very heavy.

3.4.6 Geometrics

Roadway geometrics influence pedestrian behaviour in terms of risk taking when crossing against the signal. When a roadway is wide, (i.e. greater than four lanes) and there is no median, pedestrians will be less likely to cross against the signal because of the greater exposure to vehicle traffic. If, however, there is a median refuge, the effective width of the roadway is reduced. Pedestrians will only have to search for appropriate gaps in a one-way flow of traffic as opposed to a two-way flow.

Similarly if the roadway is narrow, i.e. less than four lanes, then pedestrians will require less time to cross the roadway and hence require smaller gaps in order to cross.

3.4.7 Summary

In summary the behaviour of pedestrians is influenced by a number of distinct yet interrelated factors. For example, the degree to which pedestrians adhere to the traffic signal depends on the traffic volume, the climate and their perceived delay. The assessment of the impact of each of these factors is primarily qualitative with very few quantitative measures. Considerable research could be undertaken on each of the above factors.

4.0 SYSTEM PRINCIPLES

Section 4.0 provides background on the operation and design of a traffic signal system.

4.1 INTRODUCTION

In an urban setting, it is often necessary to install traffic control devices to provide motorists with a clear understanding of the operation of the roadway. The primary emphasis of traffic control devices is to maintain the safety of the public, with the secondary objective of minimizing travel time and delay.

The operating rule at intersections without any traffic control devices is the "right-hand rule" which states that if two vehicles approach an intersection (at right angles) simultaneously, the vehicle to the drivers right has the right-of-way. There are, however, many instances when this rule is difficult or impractical to implement.

At a location where a major street intersects with a minor street it is not logical to keep the right-hand rule and therefore a STOP or YIELD sign is installed for the minor street. This allows the traffic on the major street to flow freely and allows the minor street traffic to cross when a sufficient gap in the major street traffic occurs.

In the case where two major streets intersect, it is not sufficient or practical to install a STOP or YIELD sign. If such a traffic control device were to be installed, the "minor" street traffic would experience significant delay and long queues of traffic would form. Consequently, the intersection is signalized.

A traffic signal serves to allocate predetermined quantities of time to the movement of traffic in a particular direction(s). The traffic signal separates vehicles temporally rather than spatially (i.e. a grade separation). Once this temporal separation has been implemented for a single intersection it is often necessary to accomplish this same task for a number of intersections, particularly in an urban situation.

When there are a number of consecutive, relatively closely spaced signalized intersections, it is often necessary to coordinate the signals. In a coordinated system of traffic signals, a vehicle travelling along a particular corridor will be able to pass through a series of signals with little or no delay. This implies then, that the signal indication in the direction of travel will be green when the vehicle arrives at the intersection.

To more fully understand the concept of signal coordination two other concepts must first be developed, as below.

4.2 VEHICLE TRAJECTORIES

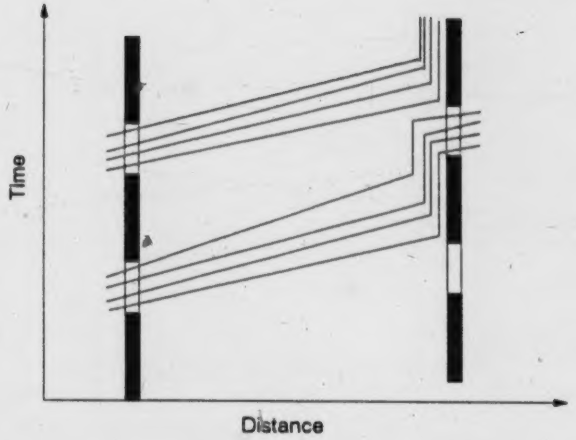
One of the key tools used in signal coordination is the Time-Space Diagram (TSD) which is used to plot vehicle trajectories. The trajectory of a vehicle through time and space (distance) can be plotted on a graph to provide a visual representation of the operational parameters of a motor vehicle within the roadway network. Figure 4.1 illustrates three TSDs each showing a different level of coordination.

The speed of vehicles can be determined since both the travel distance and the travel time are known for each vehicle. The degree to which the vehicles are platooned can be determined by observing how closely grouped the plot of the trajectories is. For example, if the vehicles are platooned, the plotted lines will all be grouped together on the TSD, whereas if the vehicles are arriving in a random pattern the plotted lines will also occur randomly.

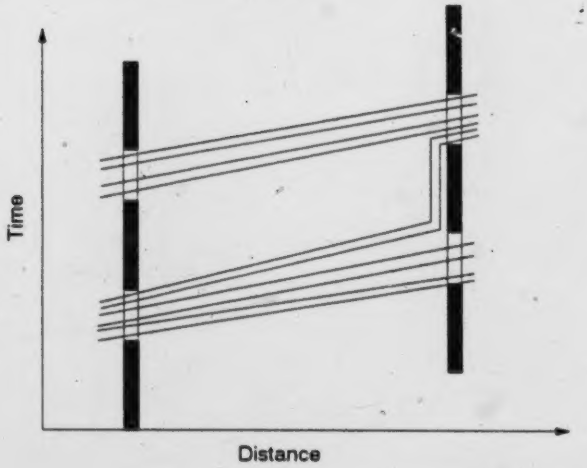
Conversely, if the free flow travel speed and the distances are known, the TSD can be derived synthetically using either random or deterministic vehicle arrival patterns.

4.3 SIGNAL TIMINGS

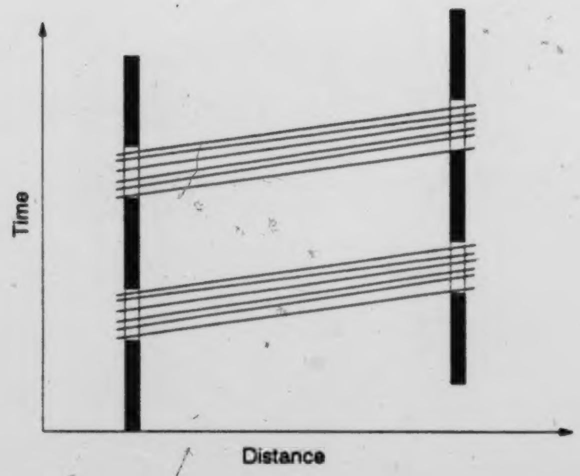
An integral component of signalizing an intersection is the determination of the traffic signal timings. The signal design consists of three principal components: Phasing, Cycle Time, and Green Allocation.


Time
Distance

(a) Poor Coordination


Time
Distance

(b) Good Coordination


Time
Distance

(c) Excellent Coordination

FIGURE 4.1

COORDINATION TIME-SPACE DIAGRAMS

The first step when designing a signal is to determine the "cycle structure, i.e. the grouping of intersection movements into phases and the sequence of the phases"[7]. Once the cycle structure has been determined, it is necessary to ascertain the cycle time, i.e. the time from the beginning of one green interval to the beginning of the next green interval for any one specific movement. The cycle time is determined by examining the vehicle and pedestrian requirements. Typically a cycle time that minimizes total intersection delay for the vehicle traffic is determined first. Once this cycle time has been determined the minimum cycle time for pedestrians is determined. The minimum pedestrian cycle time is the sum of the longest walk and clearance periods for each phase. The pedestrian cycle time typically governs in cases where the roadways are quite wide, thereby requiring lengthy pedestrian clearance intervals. The longer of the two cycle times is selected as the base cycle time for the intersection.

Once the cycle structure and the cycle time have been determined, the next task is to allocate the green time to each phase. There are a number of methodologies that can be used to allocate the green time including:

- "proportioning volume/saturation flow rates
- balancing or weighing the probabilities of clearance
- delay minimization
- congestion management[1]"

4.4 SIGNAL COORDINATION

There are two basic types of traffic signal coordination: linear (a system with open ends) and network (a system of closed loops). Linear coordination is the simplest form of traffic signal coordination that requires traffic signals along a linear corridor to be coordinated. Network signal coordination involves the coordination of traffic signals in a network that do not necessarily lie along a linear corridor. Linear coordination may form a component of the network coordination.

Any one or combination of the following objectives are utilized when designing signal coordination:

- minimize the number of stops;
- minimize the delays;
- minimize the travel time;
- maximize throughput of specific intersection approaches; and,
- control queues at specific locations.

Although some of these objectives conflict, it is important to be aware of all of the objectives when designing the signal coordination.

There are three principal methods by which traffic signals are coordinated: throughbands, greenbands and cyclic flow profiles.

Throughbands are developed using Time-Space Diagrams and they indicate the trajectories of vehicles passing unimpeded through a series of traffic signals. The bounds of the throughband are delineated by straight lines based on a constant operating design speed. Teply and Hunt[18] have shown that the use of throughbands can be misleading and often does not yield the optimal design.

Greenbands are similar to throughbands in that greenbands are maximized between adjacent pairs of signals. The emphasis is on pairs of signals rather than a series of signals. The main difference between throughbands and greenbands is that the greenband technique makes allowances for the discharge of queued vehicles when determining the signal offsets. This difference is illustrated in Figure 4.2.

The cyclic flow profile (CFP) technique is used by the TRANSYT[13] computer program to optimize traffic signal timings. The CFP indicates the average patterns of arrival and discharge rates that occur at the signal stopline over a complete signal cycle. The CFP method is a numerically intensive and complex technique that is particularly suitable for complex roadway networks.

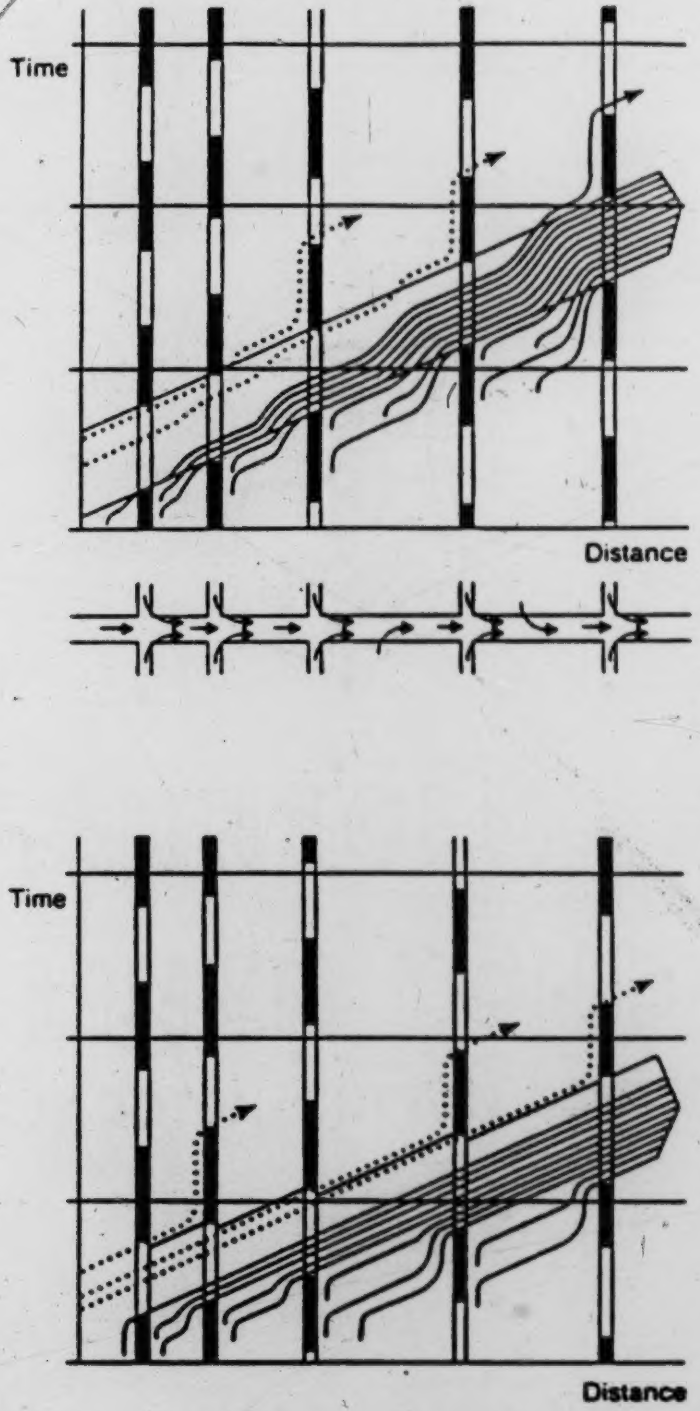

Time
Distance
Time
Distance

FIGURE 4.2
GREENBAND AND THROUGHBAND COORDINATION

The objective is, therefore, to align the green intervals with the vehicle arrivals as best as possible. Figures 4.1a - 4.1c illustrate examples of poor, fair and excellent signal coordination, respectively. Each time that a portion of the vehicle trajectory is represented with a vertical line, the vehicle is stopped and hence delayed.

Complications do arise even when attempting to coordinate a linear set of traffic signals. Specifically, when there are vehicles entering into the corridor at intermediate points such as site accesses or parking lots or if there is a significant number of vehicles turning onto the corridor from side streets the coordination is complicated because of the on-turning vehicles queuing at the downstream signal. Figure 4.3 illustrates the problem more clearly.

The on-turning vehicles form queues at the downstream signal which will impede the progress of the mainstream vehicles unless the queues have been dispersed before the first mainstream vehicle arrives at the signal.

The signal coordination illustrated in Figures 4.1 and 4.3 are simplified cases in which the roadway is assumed to have one-way traffic flow. In cases where there is two-way traffic flow it becomes more difficult to coordinate the signals for both directions of travel. For two-directional flow, the signals are usually coordinated in the direction that experiences the highest traffic volumes during the design period.

4.5 ARRIVAL DISTRIBUTION

The arrival pattern of vehicles at an intersection also impacts whether or not the signal is suitable for coordination with an upstream signal. Figure 4.4 illustrates two types of vehicle inflow distributions. In the case where the major flow is significantly larger than the two minor inflows, (Figure 4.4a) it is possible and desirable to coordinate the signal with the upstream signal such that the major flow of traffic will arrive at the intersection during the green interval. Where the inflow and "major" flow volumes are all approximately equal (Figure 4.4b), there is little benefit in coördinating the signal with an upstream signal.

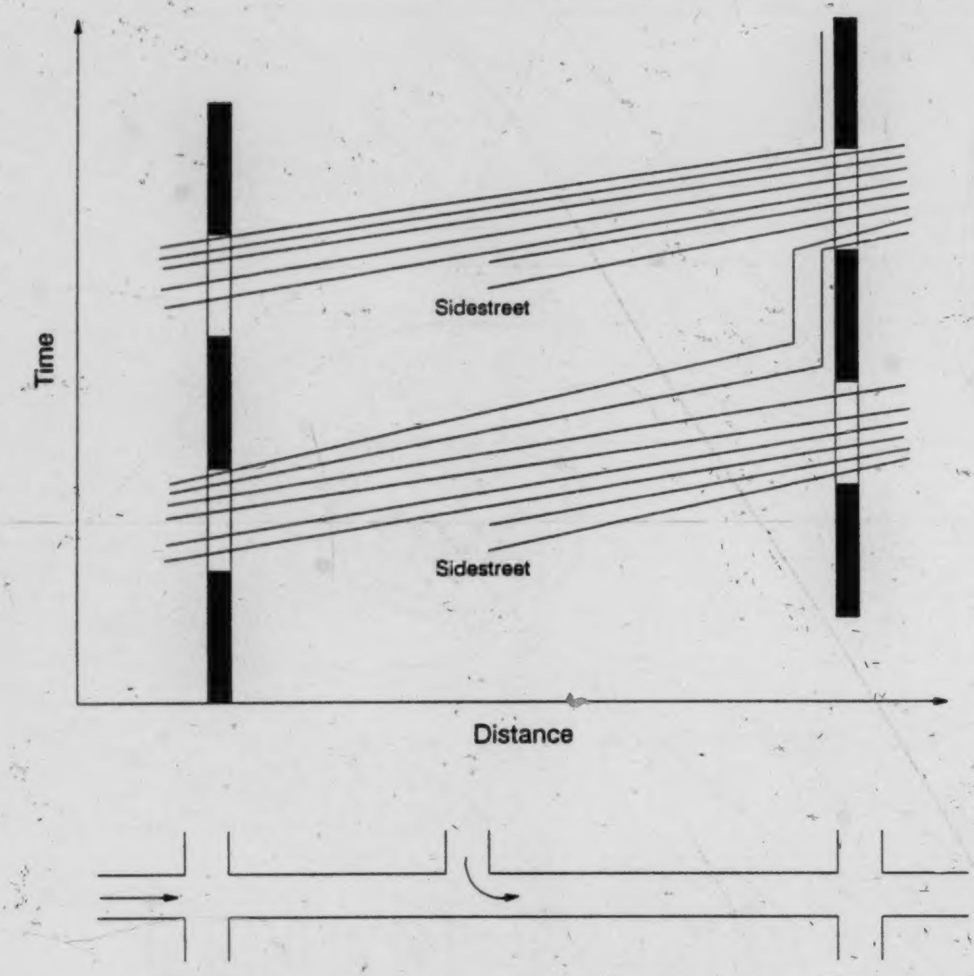

Sidestreet
Time
Sidestreet
Distance

FIGURE 4.3

COORDINATION TSDS WITH SIDESTREET TRAFFIC

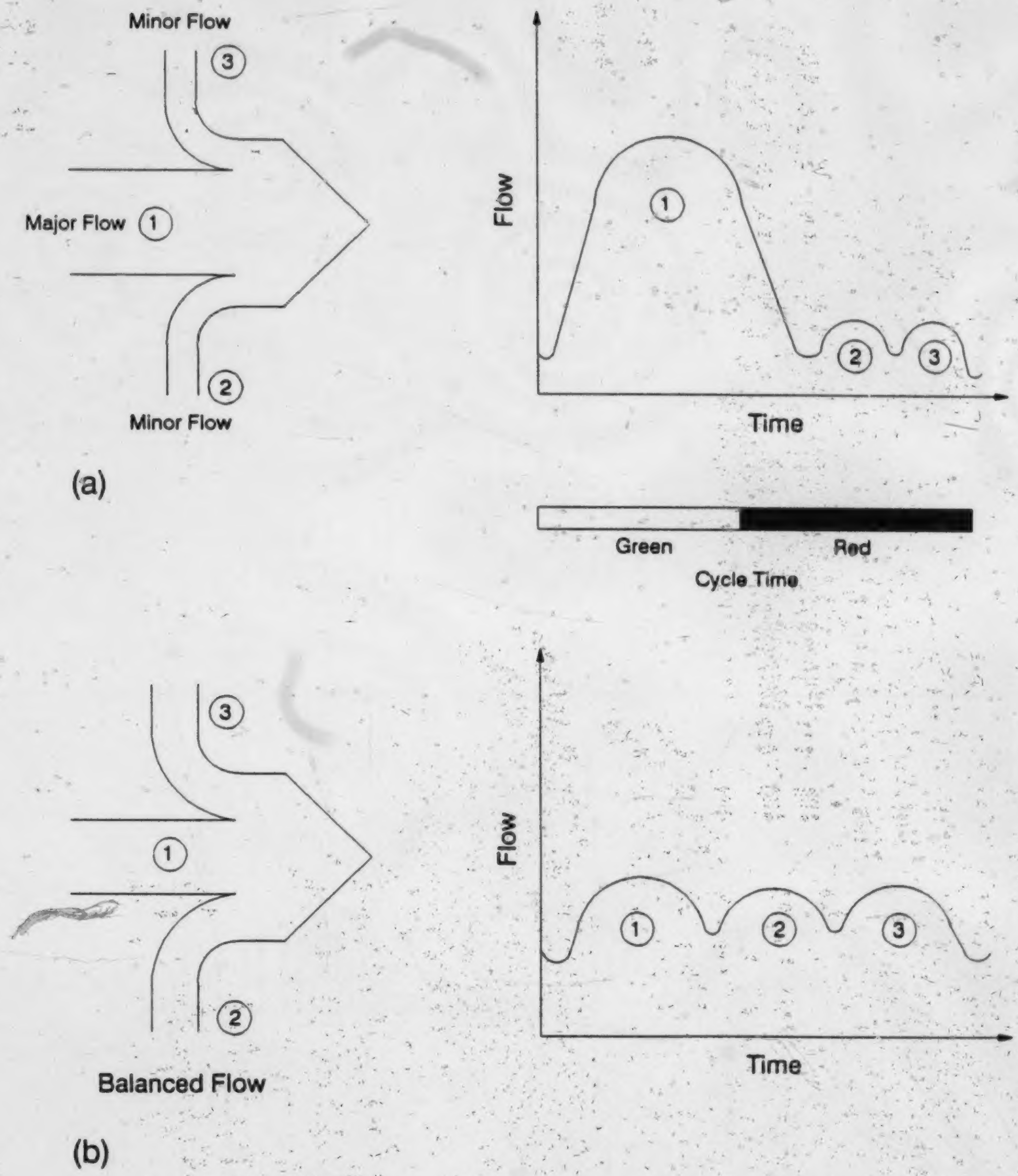

Minor Flow
③
Major Flow ①
②
Minor Flow
(a)
Flow
①
②
③
Time
Green
Red
Cycle Time
③
①
②
Balanced Flow
(b)
Flow
①
②
③
Time

FIGURE 4.4

VEHICLE INFLOW DISTRIBUTIONS

The signal should, however, be coordinated with a downstream signal because the signal can be used to create a cyclic flow profile as illustrated in Figure 4.4a. One of the benefits of a signal is that it can form desirable cyclic flow profiles that will facilitate signal coordination. However, if there are major sources of inflowing traffic downstream of the signal, then the cyclic flow profile will resemble that of Figure 4.4b and no positive results will arise from coordination.

4.6 SUMMARY

As illustrated by the above discussion the design of an effective and efficient traffic signal system is a complex task. There are a number of tools available to the transportation engineer to assist in the design task, but as noted in Chapter 2, none of them adequately address the role of the pedestrian within the system.

5.0 COMPUTER MODEL

Section 5.0 describes the structure, assumptions, input and output of the model.

5.1 INTRODUCTION

The PEDXING computer model was developed on an IBM PC-AT clone running at 10 Mhz with a 40 MB hard drive. The program can be run on slower machines without a hard drive but it is not recommended due to the significant performance penalties caused by the lack of a hard drive.

The software that was used to develop the program was Microsoft FORTRAN 4.1.

The program was designed to maximize flexibility for modelling a variety of geometric and operational conditions. The program models a network that consists of a single "representative" lane that passes through two traffic signals and a signalized pedestrian crosswalk. The model allows for different cycle times for each set of signals and the user specifies the signal offset for the second intersection signal relative to the first intersection signal.

5.2 OVERALL PROGRAM STRUCTURE

The model was developed incrementally in order to minimize the possibility of software bugs propagating through the program and to simplify program debugging. The model consists of a total of eight distinct modules of which one is a sub-routine. Figure 5.1 illustrates the general flow chart for the program. The first module opens up the input and output files, reads in and checks the input data and writes the input data to the output file.

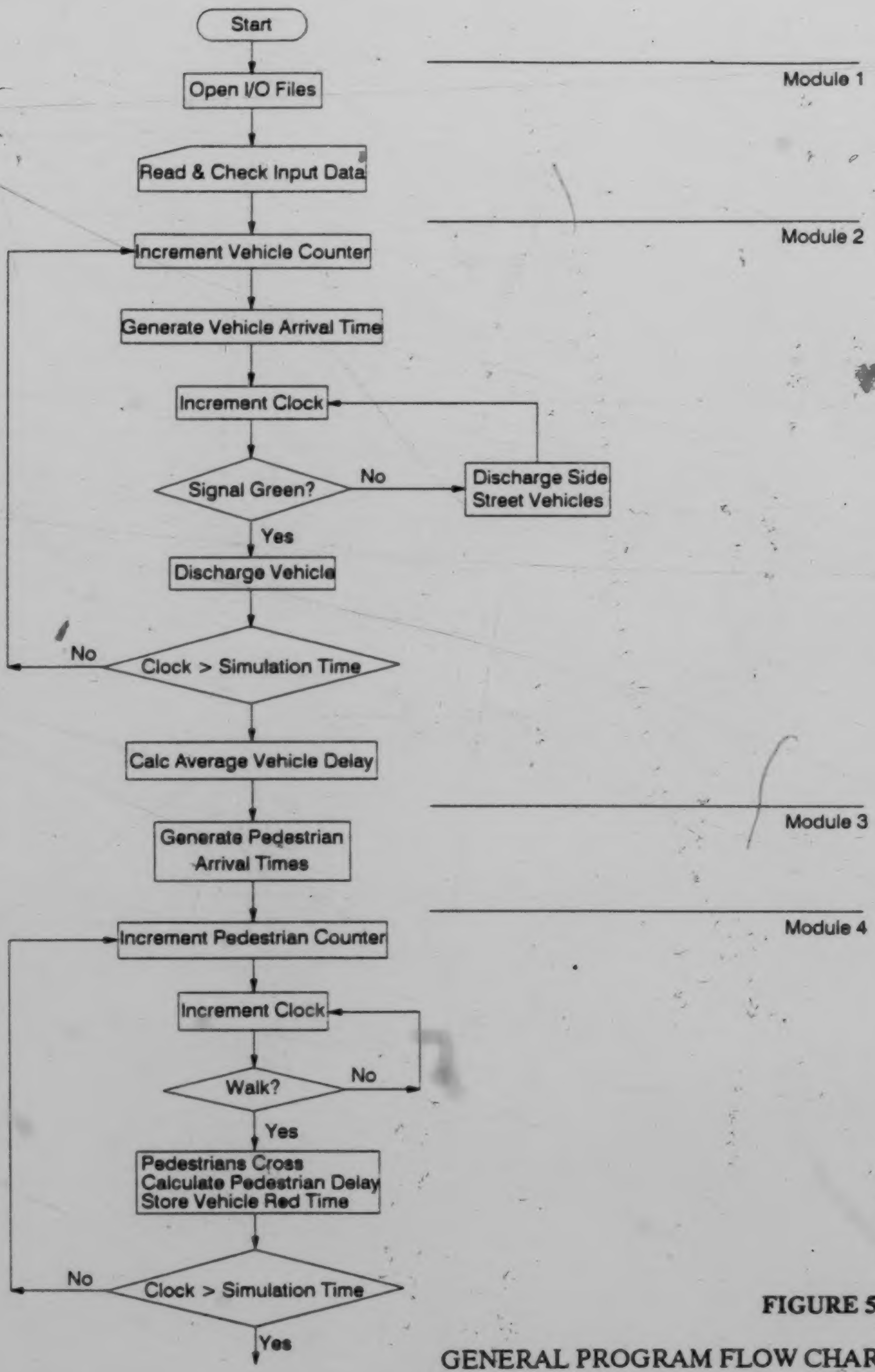

Start
Open I/O Files
Module 1
Read & Check Input Data
Module 2
Increment Vehicle Counter
Generate Vehicle Arrival Time
Increment Clock
Signal Green?
No
Discharge Side Street Vehicles
Yes
Discharge Vehicle
No
Clock > Simulation Time
Calc Average Vehicle Delay
Module 3
Generate Pedestrian Arrival Times
Module 4
Increment Pedestrian Counter
Increment Clock
Walk?
No
Yes
Pedestrians Cross
Calculate Pedestrian Delay
Store Vehicle Red Time
No
Clock > Simulation Time
Yes

FIGURE 5.1

GENERAL PROGRAM FLOW CHART

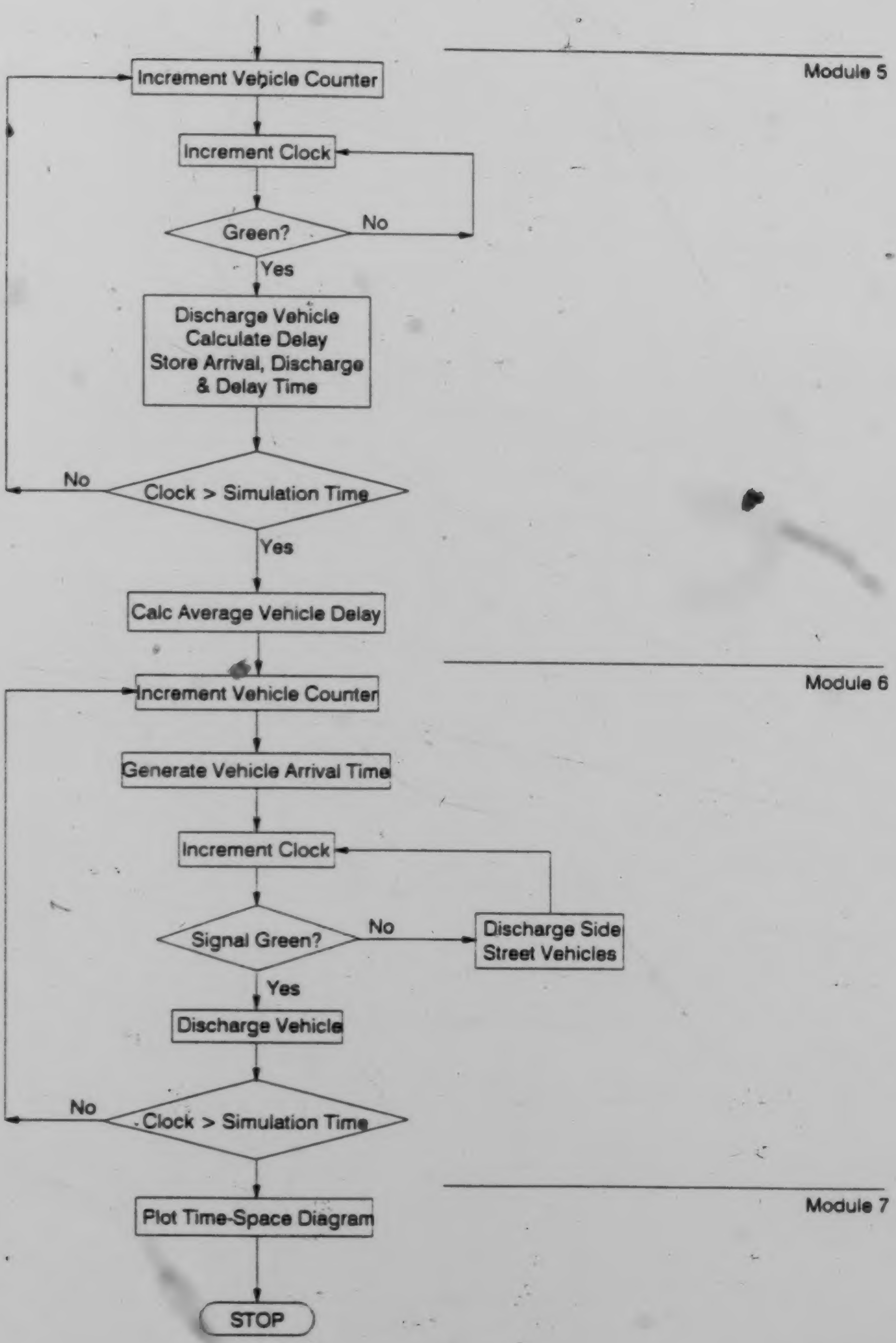

Module 5
Increment Vehicle Counter
Increment Clock
Green?
No
Yes
Discharge Vehicle
Calculate Delay
Store Arrival, Discharge
& Delay Time
No
Clock > Simulation Time
Yes
Calc Average Vehicle Delay
Module 6
Increment Vehicle Counter
Generate Vehicle Arrival Time
Increment Clock
Signal Green?
No
Discharge Side
Street Vehicles
Yes
Discharge Vehicle
No
Clock > Simulation Time
Module 7
Plot Time-Space Diagram
STOP

FIGURE 5.1

GENERAL PROGRAM FLOW CHART continued

The second module generates the vehicle arrival times and passes them through Intersection #1. This second module calculates the uniform delay caused by the traffic signal and stores the vehicle arrival and departure times and vehicle delay in an array. On-turning traffic is introduced into the network during the red interval. There are no delay calculations for the on-turning traffic at the first intersection. The data for both the through and on-turning traffic is written to the output file.

The third module generates the pedestrian arrival times and stores them in an array.

Module 4 takes the pedestrian arrival times from module 3 and processes them through the pedestrian crossing. In this module, checks are made to see if the pedestrian WALK signal is active and if so, allows pedestrians to cross. All of the pedestrians that are queued at the signal are discharged simultaneously and the delay associated with each pedestrian is calculated and written to the output file. If the user has specified that the pedestrian signal is not coordinated with the up- and downstream signals, then the pedestrian WALK interval can occur when the signal is activated and if the minimum vehicle green interval has been exceeded. If the pedestrian signal is coordinated then the pedestrian signal is only activated at specific times when coordination is facilitated. The pedestrians are constantly arriving and queued during the pedestrian DONT WALK period which includes the pedestrian clearance period. This module writes to the output file and stores in an array the time of the beginning of each vehicle red interval for use in the next module.

In module 5, the vehicles discharged from the upstream signal are processed through the pedestrian crossing. The vehicle arrival times are calculated by adding the vehicle travel time (from Intersection #1 to the crosswalk) to the departure time from Intersection #1. The model checks when the vehicle red intervals occur (from module four) and queues the vehicles accordingly. The individual vehicle delays are calculated and the vehicle arrival and departure times are stored in an array with the vehicle data from Intersection #1 as well as written to the output file. The average vehicle delay caused by the crosswalk and the total average delay is calculated and written to the output file.

The sixth module is similar to the first module except that the results of the fifth module are used to determine the arrival and discharge times of the vehicles at Intersection #2. As before, the vehicle arrival times are calculated by adding the vehicle travel time (from the pedestrian crosswalk to Intersection #2) to the departure times from the pedestrian crosswalk. The current signal phase is checked and vehicles are processed accordingly. During the red interval the vehicles are queued for discharge during the next green interval. The average vehicle delay is calculated for the signal and for the overall system and is written to the output file. The arrival and discharge times are also stored in an array with the data from the previous modules.

The seventh module takes the vehicle arrival and discharge times determined in the previous modules and prints out a plot of vehicle arrival and discharge times for a time-space diagram (TSD). The size of the plot is determined by the user specifying the first and last vehicle to be plotted. The vehicle number is plotted to facilitate the matching of points when drawing the lines in for the TSD.

The eighth module is a subroutine used to generate random numbers for use in generating vehicle and pedestrian arrival times.

Each of these modules is a distinct element within the program. There is some repetition of source code that may allow for the creation of subroutines at some future point.

5.3 PREVIOUS MODELS

The PEDXING model was developed from a single intersection model originally developed by Chuan Kua. Mr. Kua's model considered a single isolated intersection and was used to determine the average delay incurred as a result of the operation of an oversaturated signalized intersection. The single intersection model most closely resembles modules two and seven of the PEDXING program. Nonetheless, the single intersection model has been modified to accommodate the requirements of the PEDXING model. Specifically, the algorithm's used to check for the green interval, and to determine if the vehicle is allowed to discharge have been changed. In addition, a different pseudo-random number generator was used in the PEDXING program. Mr. Kua's program allowed for over-saturated conditions which are not allowed in the PEDXING model.

A shifted negative exponential distribution was used for the arrivals in both models.

5.4 MODEL ASSUMPTIONS

5.4.1 Introduction

With any computer program that attempts to simulate a real world situation, certain assumptions are intrinsic to the proper functioning of the model. It is crucial that the user clearly understands all of these assumptions before utilizing the model and particularly before applying the results of the model.

5.4.2 V/C Ratio

One of the key assumptions within the model is that the model is designed to work only for main street Volume to Capacity (V/C) ratios of less than 0.80. If the roadway network has volumes that exceed this V/C ratio, the output is not reliable. The model considers each intersection (and the pedestrian crossing) in isolation, thereby ignoring any overflow queues that may form as well as any impact of spillback on the upstream intersection. When the V/C ratio exceeds 0.80, there are periods when overflow queues form and the effects of queue spillback are not negligible.

Before using the PEDXING model it is suggested that the V/C ratio be determined by including both the main street and on-turning traffic in the calculations.

5.4.3 On-Turning Traffic

The model assumes that the on-turning traffic arrives at a uniform rate and that it discharges only during the main street red interval. For this reason it is suggested that the on-turning traffic volume be counted at a point downstream of, but near to, the first intersection. The volume of on-turning traffic may include left and right turning traffic coming from a sidestreet or traffic generated by a parking facility. It is important to select a location for the count such that all of the on-turning traffic is included.

5.4.4 Legal Requirements

The operation of the signals within the model assumes that there is no amber overrun by vehicles and that both pedestrians and vehicles strictly obey the traffic laws. Based on field observations of traffic and pedestrian behaviour, either the input or the output from the model may have be adjusted to reflect field conditions. If there is significant amber overrun then it may be necessary to input a green interval of actual green plus one or two seconds, depending on the degree to which amber overrun occurs.

5.4.5 Pedestrian Crosswalk

The pedestrian crossing signal operates based on pedestrians pressing the call button to activate the crosswalk signal. Until such time as a call is entered the signal will remain green for the vehicles. When a pedestrian enters a CALL, the model checks to see if the minimum vehicle green interval has passed. If the minimum vehicle green has been exceeded then when the CALL is entered the signal changes and the pedestrian crosses without any delay. If the minimum vehicle green has not been exceeded then the pedestrian must wait until the minimum vehicle green has passed before crossing. If the user has specified that the pedestrian signal is coordinated with the other signals then when a CALL is entered, the model will check to see if a coordination window is available. Until a window is available, the pedestrian signal will remain at DONT WALK.

5.4.6 Vehicle Headways

The minimum vehicle headway used by the model is 2.0 seconds. The model uses a shifted negative exponential distribution to determine the vehicle headways, with the shift being 2.0 seconds. This minimum headway implicitly assumes a maximum saturation flow rate of 1800 vphg/lane and only one lane for analysis. If a multi-lane scenario is to be modelled then an unshifted negative exponential distribution should be used.

5.4.7 Pedestrian Headways

There is no minimum pedestrian headway because typically pedestrians have a virtually unlimited discharge rate, i.e. when the WALK signal is displayed all of the pedestrians discharge within one or two seconds, unless the queue is very large. Pedestrians can arrive in groups of more than one therefore the headway distribution is determined using a negative exponential distribution.

5.4.8 Vehicle Operation

The operational characteristics of vehicles in the system are a key element of the model. The model assumes that vehicles travel at a constant speed and that they accelerate and decelerate instantaneously. Similar to other traffic models, the PEDXING program does not consider the length of the vehicle queue such that vehicles are stacked rather than queued. Due to this representation, the model calculates overall delay rather than the stopped delay.

5.5 DETAILED MODEL DESCRIPTION

5.5.1 Introduction

To facilitate future modifications to the program source code, a more detailed description of the program is presented. A complete listing of the program is listed in Appendix A.

5.5.2 Random Number Generator

The random number generator is actually a pseudo-random number generator. If the same seed number is used for each run then the same random numbers are generated. The random number generator was obtained from "*FORTRAN 77 for Humans*" Third Edition written by R. Page et al[19].

The random number generator returns to the calling program a value ranging from 0 to 1. There are three variables within the random number generator that are stored after each call to the subroutine for use during the next call to the subroutine. The seed number is utilized for only the first call to the subroutine. Subsequent calls to the random number generator do not require the seed number since the subroutine uses previously stored values of its internal variables to calculate the next random number.

The random number generator uses large double precision numbers in its calculations. The procedure for calculating a pseudo-random number is relatively standardized, with variations between methods resulting from the magnitude of the number used and the functions used to calculate terms within the algorithm. It has been found that the larger and the more precise that the numbers used in the calculations are in calculating the "random" numbers, the closer the numbers will be to be truly "random". Double precision variables contain more than twice the number of digits allowed in REAL numbers and consequently do not suffer from problems due to numeric truncation and rounding found with very large REAL variables.

5.5.3 Vehicle Headway Distribution

There are a number of headway distributions that can be used to describe the arrival patterns of vehicles. The shifted negative exponential distribution was selected for this model because it is a relatively simple model that produces satisfactory results (Refer to Section 3.2.2 for further details).

In the case of the PEDXING model, the shifted exponential distribution for headways has the form:

$$\text{Headway} = 2 - (\text{Avg Headway} * \text{LN}(1 - \text{Random Number}))$$

Strictly speaking the equation should be of the form:

$$\text{Headway} = 2 - ((\text{Avg Headway} - 2) * \text{LN}(1 - \text{Random Number}))$$

This equation produces a large number of very small headways. Therefore the equation was modified slightly to produce larger headways. In addition a scale factor was applied to the Random Number such that the average of the headways that are produced equals the requisite 3600/Volume[20]. The arrival headway graphs in Section 8 illustrate that the modified equation yielded acceptable results.

If the model were to consider multi-lane roadway configurations, it would be possible to observe headways across both lanes equal to zero seconds. To accommodate headways of less than two seconds the above equation would require that the 2 be replaced with the appropriate minimum headway. Similarly if the saturation flow rate exceeds 1,800 vehicles per hour of green, the value of τ would have to be adjusted.

G.F. Newell has shown that "delays are relatively insensitive to the form of the distribution of the arriving traffic. Thus, if the objective is simply the computation of delays, the simplest (i.e., the negative exponential) distribution should be used."[21] Therefore the use of the shifted negative exponential distribution is suitable for the determination of delay.

5.5.4 Pedestrian Headway Distribution

The pedestrian headway distribution used in the model is a negative exponential distribution. No shift was required because it is possible for a number of pedestrians to arrive and discharge simultaneously. It was assumed that the pedestrians arrive in a random manner and the function describing the arrival pattern has the form:

$$\text{Headway} = \text{ABS}(\text{LN}(1 - \text{Random Number}))$$

It should be noted that the pedestrian arrival headway function does allow for multiple simultaneous arrivals. The difficulty is that the function typically does not have more than two (2) pedestrians arriving simultaneously. At locations where pedestrian grouping is not prevalent, the function will suffice.

At locations where pedestrian grouping is prevalent it may be necessary to either modify the function describing the arrival pattern or to adjust the model input to account for the grouping.

5.5.5 On-Turn Vehicle Headways

To provide a more realistic model, on-turning traffic from side streets was incorporated. The model assumes a fixed arrival pattern and fixed arrival rate.

The user inputs the volume of the on-turning traffic, upstream of the pedestrian crossing. The model calculates the average vehicle headway as follows:

On-Turn Headway = ((3600/Cycle Time) * Vehicle Red Interval) / On-Turn Volume

The On-Turn headway is equal to the number of signal cycles per hour multiplied by the duration of the red interval for the main street traffic (i.e., total quantity of green interval time per hour for the side-street traffic) and divided by the on-turn volume.

The model assumes that there are no side-street vehicles turning on to the main roadway during the side-street red interval.

5.5.6 Operation of Vehicle Signal

The second module of the program, the operation of the vehicle traffic signal, is described in detail below. The detailed program flow chart, listed in Appendix B, and the detailed program source code, listed in Appendix A, may be referred to as needed.

The model calculates the average through traffic headway by: 3600/Through Traffic Hourly Volume; and the average on-turn headway as described in Section 5.5.5. The random number generator is initialized using the seed number so that subsequent calls to the random number generator do not require passing of a seed number (see discussion of the random number generator).

The vehicle counter is incremented and a random number is generated which is in turn used to generate a vehicle headway. The arrival time of the next vehicle is calculated by adding the headway interval to the previous vehicle arrival time. The time clock is incremented by one second. Two separate time checks are calculated: is the vehicle arrival time less than the duration of the simulation, and, is the clock time less than the simulation time. If both conditions are true then the model continues processing, otherwise the program continues to the next module.

Next, the model determines the integer value of the cycle number that is current (i.e. the first, fifth, twentieth cycle, etc.). Then it is necessary to determine how far into the cycle the clock is and subsequently which interval the cycle is at. If cycle is in the red interval (for the main street traffic) then discharge the side-street traffic. If the signal is green then check if the clock is greater than the vehicle arrival time. If the clock is less than the vehicle arrival time then the vehicle has not yet arrived at the signal and the program loops back to increment the time clock until the clock time is greater than or equal to the vehicle arrival time.

Once the clock is greater than the vehicle arrival time the program checks if the current vehicle may discharge. A DO loop creates a variable that adds a specific amount of time to the clock time to determine the vehicle discharge time. The variable is added to the clock time and the time at which the previous vehicle discharged is subtracted from the sum. If the remainder is greater than or equal to the Saturation Flow headway then the vehicle is allowed to discharge. If the remainder is less than the saturation flow headway then the vehicle will join the queue and the clock will be incremented.

When it has been determined that the vehicle may discharge the program checks for vehicle delay by subtracting the previous discharge time from the clock time to check if the remainder is greater than the saturation flow headway. If the condition is TRUE then the vehicle is assumed to be undelayed by the intersection.

The model stores the vehicle arrival and discharge times as well as the delay time in an array for use in subsequent modules of the program.

Once a vehicle has been discharged, the program loops back to increment the vehicle counter and begins the checking processes and discharge process again.

5.5.7 Operation of the Pedestrian Signal

The operation of the pedestrian signal is accommodated in modules 4 and 5 of the program. These two modules are described below.

The pedestrian arrival times that were generated in module 3 are used in module 4. The model initializes a number of variables including timers to check the phase durations throughout the operation of the signal. The pedestrian counter is incremented and the appropriate arrival time is obtained from the array. The model then checks to see if the WALK signal is activated and checks if the pedestrian arrival time is less than or equal to the clock time. If the WALK signal is active and the arrival time is less than the clock time the pedestrian is discharged and the program loops back to obtain the next pedestrian.

If the WALK signal is not active and the vehicle signal is green then the model sets up a loop for a signal timer to run the signal through each phase. The model then checks if the pedestrian counter is greater than the pedestrian volume or if the clock time is greater than the duration of the simulation. If either condition is true then the program proceeds to the next module. If the condition is not true and if the pedestrian arrival time is less than the clock time then a CALL is sent to the pedestrian signal.

If the pedestrian signal is not coordinated with the other signals the model checks to see that the minimum vehicle green has been met and that a CALL has been entered. If each condition is met, the WALK indication is provided and the pedestrians may discharge. If the conditions are not met the model loops back to increment the appropriate timers until the conditions are met.

If the signal is coordinated then the model checks to see if a coordination window is available. If a window is available then the WALK indication is provided and pedestrians discharged. If no window is available then the timers and clock are incremented until such time that a window is available.

The program checks at various points in the loop when the WALK phase is to be terminated, when the clearance phase is to be terminated and if the minimum vehicle green interval has been reached.

When all of the pedestrians have been discharged through the pedestrian crossing (for the entire duration of the simulation), the model proceeds to the next module in which the vehicles are processed through the pedestrian traffic signal.

The processing of vehicles through the pedestrian signal is similar to that of the full intersections except that instead of having a fixed-time signal, the signal activations are random. The program begins by initializing a number of variables including the vehicle counter. The vehicle counter is incremented and the first vehicle is obtained from the array. The travel time from intersection #1 to the pedestrian crossing is added to the discharge time to obtain the arrival time at the mid-block crossing. The clock is incremented and checked to see if the clock time is greater than the simulation duration.

Then the model checks to determine if the vehicle signal is red or green. If the signal is green then the vehicle is discharged. If the signal is red then the clock is advanced to the beginning of the next green interval and the vehicle is discharged. The checks for vehicle discharging are the same for the mid-block signal as for the intersection signals.

5.6 MODEL INPUT

In order to obtain output from the model a number of parameters must be input into the model:

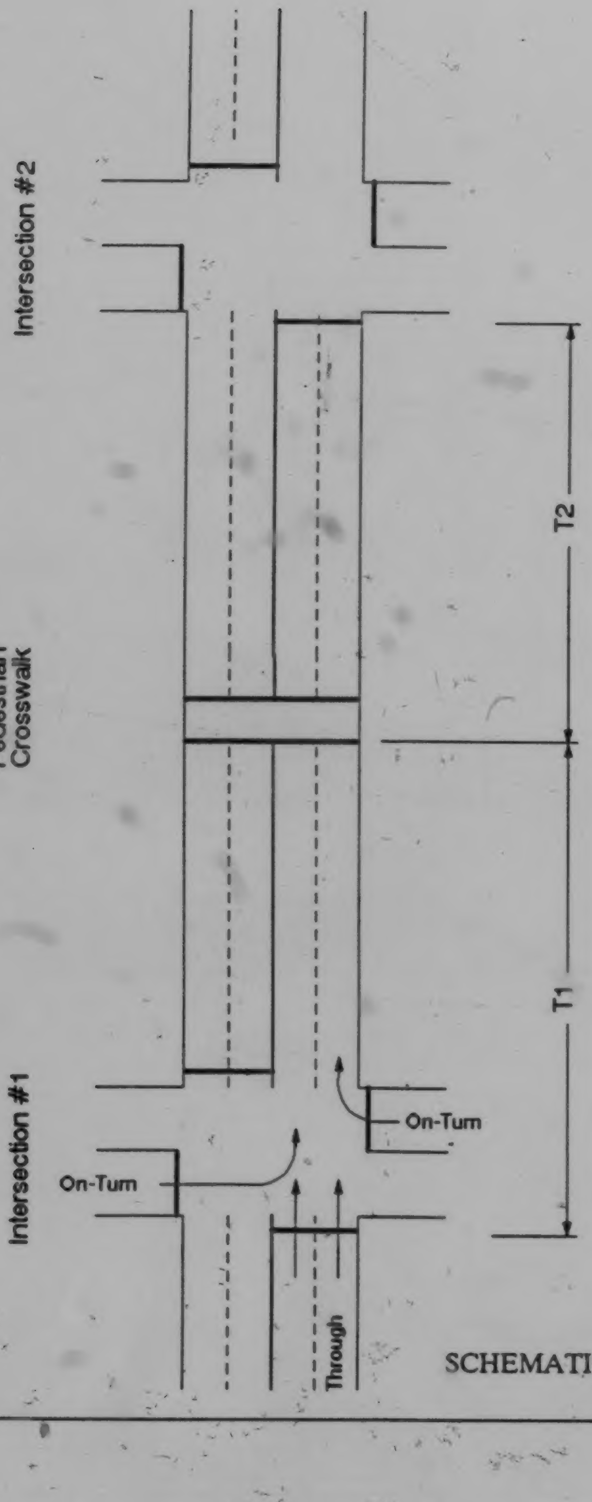
- through (or main street) traffic volume in pcu/h
- side street (or on-turning) traffic volume in pcu/h
- stopline saturation flow, pcu/h green
- duration of the simulation, in minutes
- seed number
- Intersection #1 vehicle red interval, in seconds
- Intersection #1 vehicle green interval, in seconds
- Intersection #2 vehicle red interval, in seconds
- Intersection #2 vehicle green interval, in seconds

- pedestrian volume at crosswalk in pedestrians/h
- pedestrian WALK interval, in seconds
- pedestrian clearance period, in seconds
- travel time from first intersection to the pedestrian crossing, in seconds
- travel time from the pedestrian crossing to the second intersection, in seconds
- offset of signal #2 from intersection #1, in seconds
- cycle times for each signalized intersection, in seconds
- minimum vehicle green interval at the pedestrian crossing, in seconds

All parameters must be determined before running the model either through field observations or from preliminary signal timing designs. Figure 5.2 illustrates a theoretical network suitable for simulation. Each of the input parameters is discussed below.

5.6.1 Through Volume

The input through traffic volume represents the total number of passenger car units (PCU's) crossing the stopline in the main direction of travel. This volume is the through traffic volume for the one design through lane. Left and right turning traffic is disregarded. The model calculates a V/C ratio based on the combined through and on-turn volume and the green interval for intersection #2. If the V/C ratio exceeds 0.80 the program produces a warning message and stops execution.


Intersection #1
On-Turn
On-Turn
Through
Pedestrian Crosswalk
Intersection #2
T1
T2

T1 - Distance for travel time from Intersection 1 to Crosswalk

T2 - Distance for travel time from Crosswalk to Intersection 2

FIGURE 5.2

SCHEMATIC ROADWAY NETWORK

5.6.2 On-Turning Volume

The on-turning traffic volume, expressed in PCU's per hour, is the summation of all of the left and right turning traffic from the side streets at intersection #1 that turn onto the main street. On-turning traffic may also include traffic that turns onto the roadway from adjacent land uses. Note that the model will add the travel time, from Intersection #1 to the Pedestrian Crossing, to the departure time of the on-turning traffic to obtain the arrival time at the pedestrian crossing.

5.6.3 Stopline Saturation Flow

The stopline saturation flow is the saturation flow for the design through lane expressed in pcu per hour green. There is no specified maximum or minimum value but the saturation flow must be non-zero.

5.6.4 Simulation Duration

The duration of the simulation must be entered in minutes, typically this would be 60 minutes. The model will convert the input simulation duration into seconds and subsequently express all times in seconds.

5.6.5 Seed Number

The model utilizes a hard coded random number generator which is in actually a pseudo-random number generator. If the same seed number is input each time, then the same vehicle and pedestrian headways will be generated. To overcome this difficulty it is suggested that a number of iterations of the model be run, each with a unique value for the seed number and the results averaged.

5.6.6 Vehicle Red Interval for Intersections 1 and 2

The vehicle red interval is the duration of the red phase for the through movement of Intersections 1 and 2. The vehicle red interval must be specified for each intersection. Individual red intervals have been allowed to permit the modelling of uncoordinated traffic signals. The time is given in integer seconds. The program sums the red and green intervals for each intersection signal and compares the sum to the cycle time, generating an error message if the sum exceeds the cycle time.

5.6.7 Vehicle Green Interval for Intersections 1 and 2

The vehicle green interval is the duration of the green phase for the through movement of Intersections 1 and 2. The vehicle green interval for each intersection must be specified. Individual green intervals have been allowed to permit the modelling of uncoordinated traffic signals. The time is given in integer seconds.

5.6.8 Pedestrian Volume

The pedestrian volume is expressed in pedestrians per hour. Since the model assumes strict adherence to the signal, pedestrians only cross during the pedestrian WALK phase. As well, the pedestrian WALK interval will commence immediately after a pedestrian presses the button if the minimum vehicle green interval has been exceeded.

5.6.9 Pedestrian WALK Interval

The pedestrian WALK interval is the duration of the WALK phase of the pedestrian crossing signal. The minimum acceptable WALK phase duration is 7.0 seconds as per the Canadian Capacity Guide for Signalized Intersections. If field observations reveal a high incidence of pedestrians utilizing the crossing during the clearance period, then for the purposes of modelling, it may be necessary to increase the duration of the pedestrian WALK phase and decreasing the duration of the clearance phase. In this manner the overall length of the pedestrian phases is unchanged yet more pedestrians will be "allowed" to cross.

5.6.10 Pedestrian Clearance Period

The pedestrian clearance period is the summation of the duration of the flashing DONT WALK phase and solid DONT WALK phase, in seconds. The duration of this period is dependent on the width of the roadway and the average walking speed of the pedestrians. The minimum duration of the clearance phase is obtained by dividing the width of the roadway by the walking speed of the pedestrians and rounding the result up to the next integer value, i.e. 18.5 m / 1.2 m/s = 15.4 s which would round up to 16.0 seconds.

5.6.11 Travel Times

The travel time, given in seconds, is the time required to travel from Intersection #1 to the pedestrian crossing, and from the pedestrian crossing to Intersection #2. These values can be obtained either through field observations or by assuming a vehicle operating speed and calculating the travel time.

5.6.12 Offset

The signal offset is the time, in seconds, that the start of the green interval for Intersection #2 is "offset" relative to the start of green interval for Intersection #1. In a coordinated signal system the offset is typically equal to the travel time from Intersection #1 to Intersection #2. The offset may, however, in cases where there is a large volume of on-turning traffic, be less than the travel time to allow queue's formed by the on-turning traffic to dissipate before the arrival of the through traffic.

5.6.13 Cycle Time

The cycle time is the time in seconds from the beginning of green to the beginning of green for any one movement.

The cycle time for each of the two intersection signals must be input. This is to allow for the modelling of off-peak conditions when the cycle time for one signal might be different from that of the other signal.

5.6.14 Minimum Vehicle Green Interval

The minimum vehicle green interval is the minimum duration of the vehicle green interval of the pedestrian signal. This value is typically not less than 20 seconds. If a zero value is entered for the minimum vehicle green then the pedestrian WALK phase may be activated at any time, even if the vehicle green phase was activated only 1 second previously. There is no restriction on this value.

5.6.15 Time-Space Diagram Output Parameters

It is necessary to specify the first and last vehicle numbers to be plotted on the TSD. For example if only a small portion of the TSD is required then the vehicle numbers may be quite close together, e.g. 120 and 130. The numbers must be entered as integers with the lower number first.

5.6.16 Coordination

The user has the option of having the pedestrian crosswalk tied into the coordination of the up and downstream signals. If a 'Y' is entered into this field then the pedestrian crossing will be coordinated, all other input will result in the random operation of the pedestrian signal.

5.6.17 Output Options

The user has two choices for output: to produce a detailed report or a summary report and to produce a plot for a Time-Space Diagram or not.

6.0 MODEL TESTING

Section 6.0 outlines the procedures used in the development and testing of the model.

6.1 MODEL DEVELOPMENT

The PEDXING program was developed on a modular basis in order to ensure that the first module was operating correctly before proceeding to the development of the second module etc. Each module was developed in succession, with the previous modules being fully tested before the next was developed. It should be noted that occasionally input requirements for a module would require the modification of a previous module. The process of program development was iterative, with each subsequent iteration refining the operation of the overall program.

6.2 MODEL TESTING

The PEDXING model was tested by analyzing the output data using a computer spreadsheet to present both numerical and graphical summaries of the program operation. Time-space diagrams (TSDs) and queueing-diagrams were used to analyze the data in a graphical manner.

The input data for the test case was loosely based on the 87 Avenue network between 112 Street and 114 Street. The input data is listed in Table 6.1.

TABLE 6.1

MODEL TESTING INPUT DATA

Through traffic volume (pcu/h)	500.
Side street on turn traffic volume	100.
Stopline saturation flow (pcu/h gr)	1550.
Duration of simulation (minutes)	60
Seed Number (odd three digit)	815
Vehicle Red Interval #1 (seconds)	45.
Vehicle Green Interval #1 (seconds)	45.
Vehicle Red Interval #2 (seconds)	45.
Vehicle Green Interval #2 (seconds)	45.
Pedestrian volume (peds/h)	100
Pedestrian green interval (seconds)	8
Pedestrian clearance period (seconds)	17
Travel time (Int.1 to ped crossing, seconds)	10
Travel time (Ped crossing to Int.2, seconds)	10
Signal Offset (seconds)	37
Intersection #1 cycle time (seconds)	90
Intersection #2 cycle time (seconds)	90
Minimum vehicle green interval at ped X-ing (sec)	40
PEDXING coordinated with signals (Y/N)	N
Print the Time Space Diagram (Y/N)	N
Produce detailed report	Y

The queuing diagram in Figure 6.1 illustrates the operation of Intersection #1, showing the arrival times and rates and the departure times and rates. As indicated by the plot of the arrival times, the arrival rate is constant but random. The randomness is denoted by the fluctuations in the plot of the arrival times. If the arrival rate was uniform, the plot of the arrival times would be perfectly linear, with no fluctuations to denote the varying headways. Plots of a smaller time interval, 100 seconds rather than 900 seconds, in Figures 6.4 to Figure 6.6, illustrate the fluctuations more clearly.

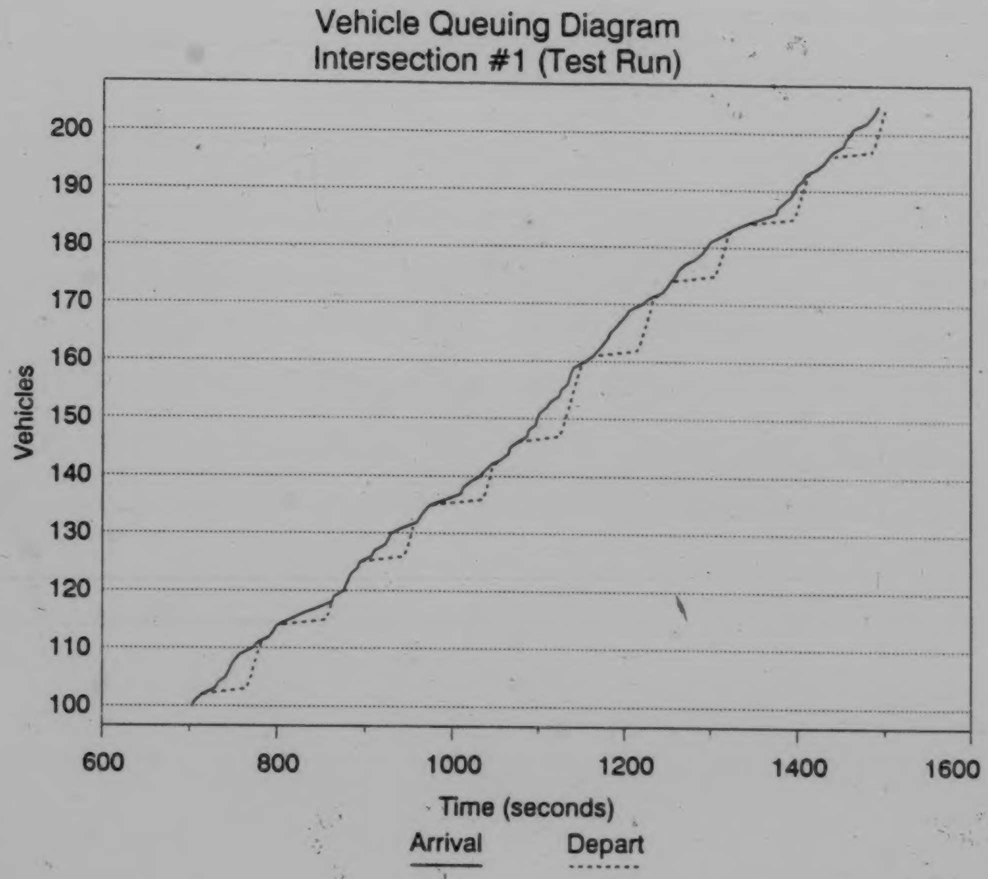


FIGURE 6.1

VEHICLE ARRIVAL AND DEPARTURES INTERSECTION #1
LARGE SCALE

The queuing diagram in Figure 6.2 plots the vehicle arrival and departure times at the pedestrian crosswalk. For the majority of the time interval shown, the vehicles were unimpeded by the pedestrian crosswalk. Vehicles 103 to 115, 133 to 136, and 166 to 195 were, however, impeded by the pedestrian crosswalk. The magnitude of the delay incurred by any single vehicle can be obtained by measuring the difference between the arrival time and the departure time (a horizontal line between the two plotted lines) on the graph. The area enclosed by the two plots is equivalent to the total delay incurred by the vehicles at the crosswalk.

The queuing diagram plotted in Figure 6.3 for Intersection #2 is similar to the queuing diagram in Figure 6.2. A few vehicles in the total vehicle stream are impeded by the second intersection.

Overall, the example shown in Figures 6.1 - 6.3, illustrates good signal coordination. This is evidenced by the relatively few occurrences where the plot of the arrival and departure times diverge.

The model output was further verified by examining the clock times when the pedestrian signal was activated (i.e. the vehicle signal indication was RED) and comparing them to the vehicle arrival times. Those vehicles that arrived during the crosswalk RED interval should and did incur delay. The clock times at which the pedestrian WALK interval began were compared to the pedestrian arrival times. Again, similar to the vehicles, if pedestrians arrive during the DON'T WALK phase they should incur delay. These checks were accomplished via both numerical and graphical means. A plot of the TSD served to illustrate the behaviour of the vehicles at each signal and also provided an estimate of the magnitude of the delay incurred by the vehicle at the signal.

An example of an INPUT file and the output, including a portion of the Time-Space Diagram, can be found in Appendix C.

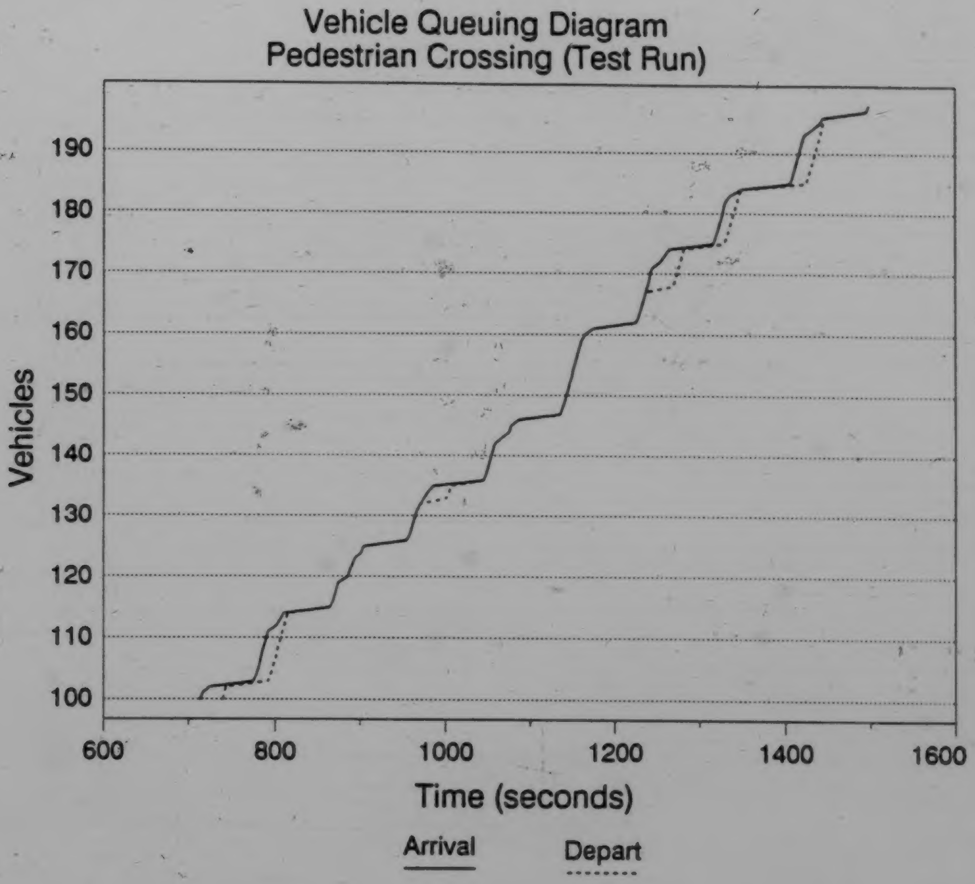


FIGURE 6.2

VEHICLE ARRIVAL AND DEPARTURES PEDESTRIAN CROSSING
LARGE SCALE

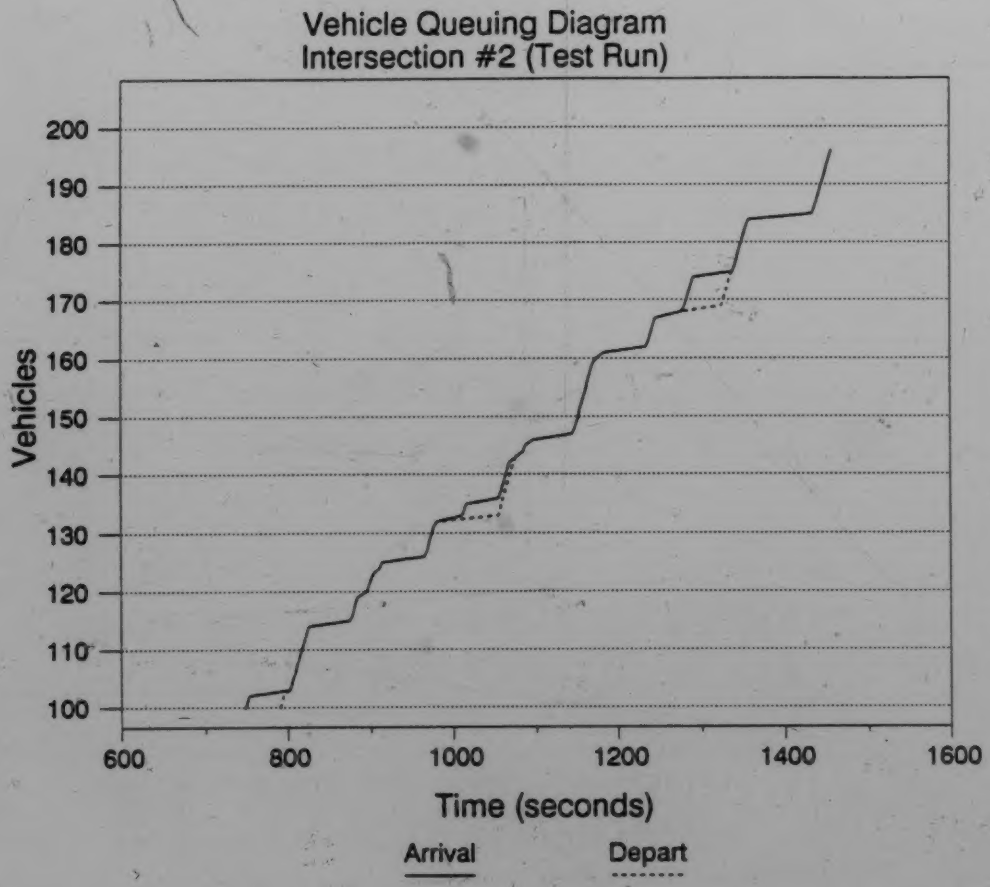


FIGURE 6.3

VEHICLE ARRIVAL AND DEPARTURES INTERSECTION #2
LARGE SCALE

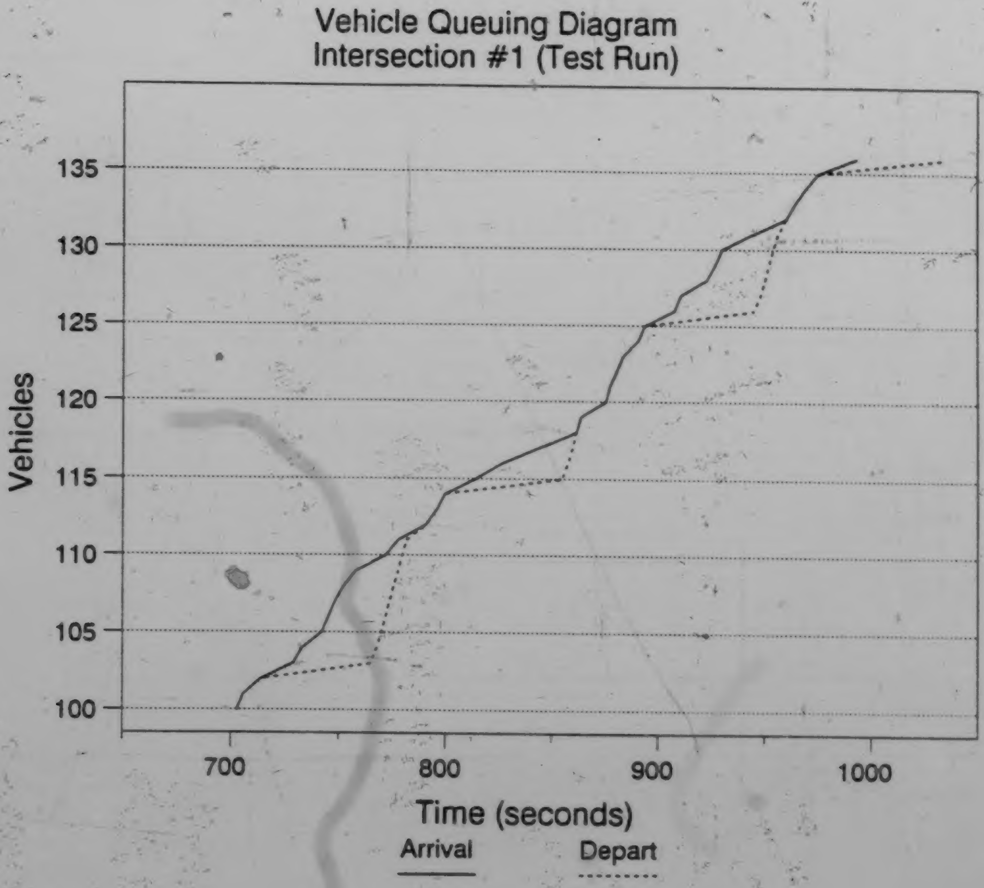


FIGURE 6.4

VEHICLE ARRIVAL AND DEPARTURES INTERSECTION #1
SMALL SCALE

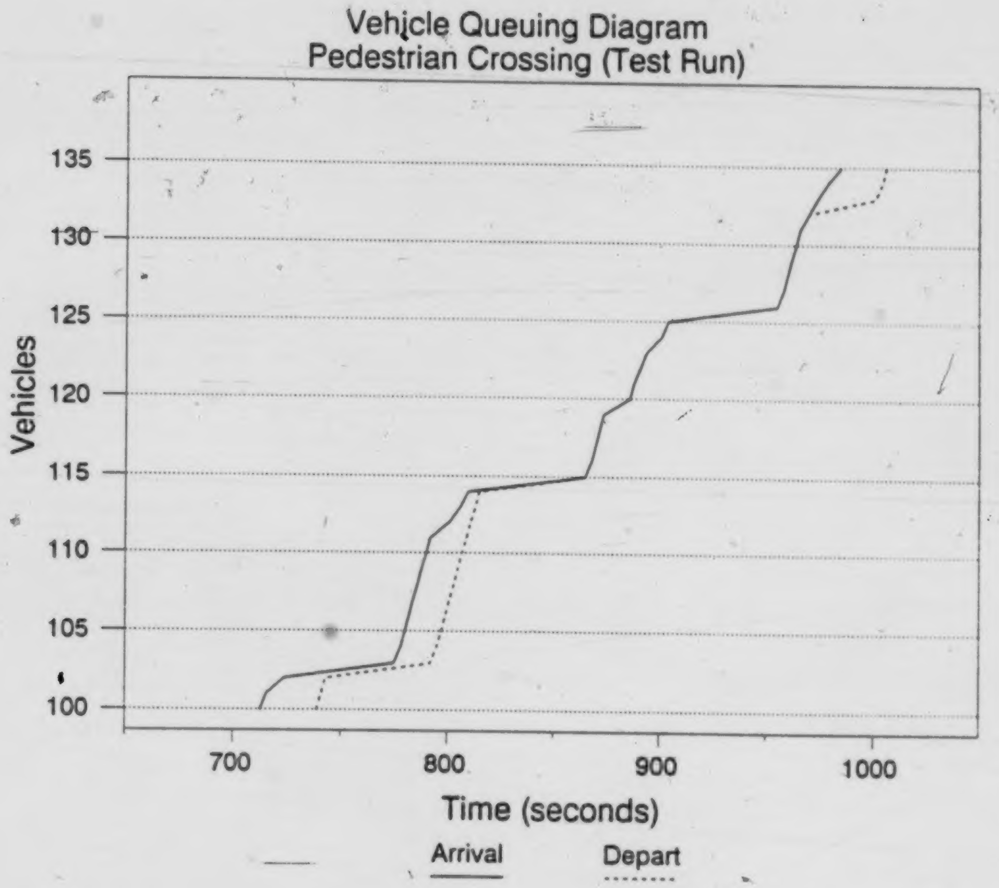


FIGURE 6.5

VEHICLE ARRIVAL AND DEPARTURES PEDESTRIAN CROSSING SMALL SCALE

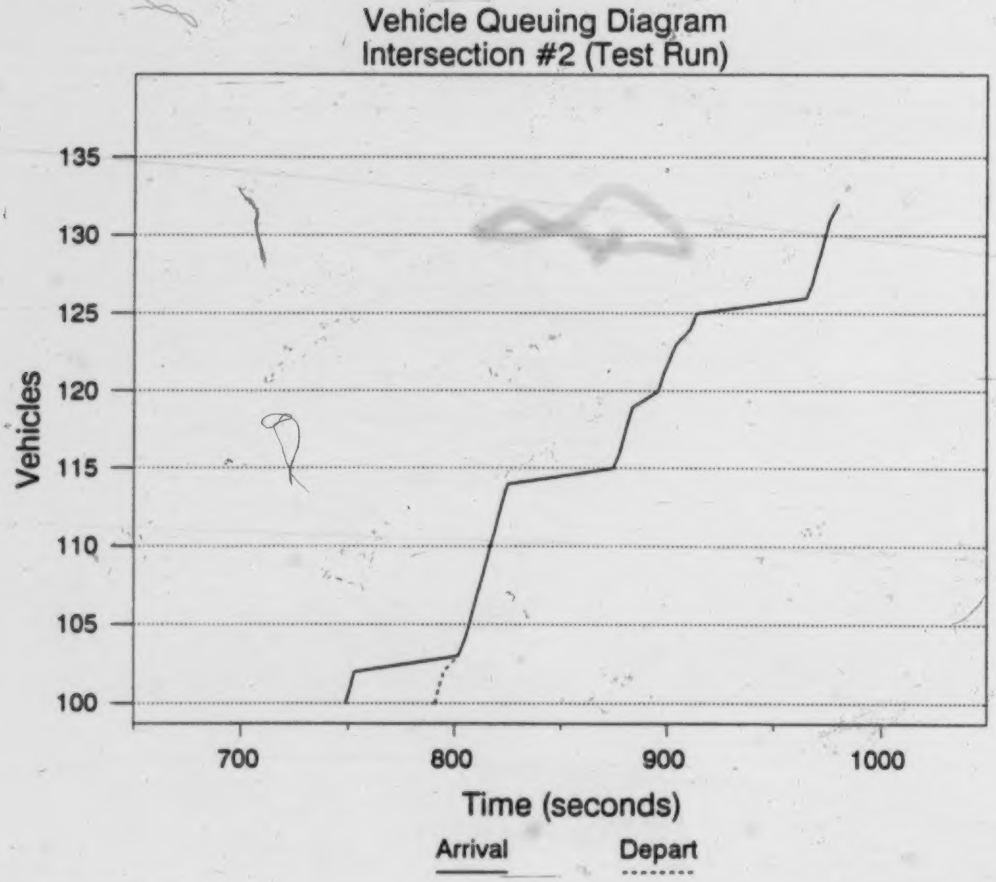


FIGURE 6.6

VEHICLE ARRIVAL AND DEPARTURES INTERSECTION #2
SMALL SCALE

7.0 DATA COLLECTION

Section 7.0 discusses the data collection program that was undertaken in order to verify the model output.

7.1 INTRODUCTION

To provide the initial verification of the model, a limited quantity of data was collected. The objective of the data collection program was to provide actual field data for input into the model and for comparison of the program output with the actual network operation. The field data were manually analyzed to determine the average delay per vehicle at each traffic signal for comparison to the model output.

7.2 DATA COLLECTION PROGRAM

7.2.1 Locations

In consultation with the City of Edmonton Transportation Department, two locations were chosen for the data collection program: 87 Avenue from 112 Street to 114 Street, illustrated in Figure 7.1; and, 109 Street from 82 Avenue to 76 Avenue, illustrated in Figure 7.2, in Edmonton, Alberta, Canada.

87 Avenue bisects the University of Alberta in an east-west direction, with the majority of the University of Alberta campus on the north side and the University of Alberta Hospitals on the south side. The traffic signals were not coordinated and did not have the same base cycle time, due to nearby road closures because of LRT construction.

109 Street is a six lane divided arterial roadway that runs in a north-south direction, between two residential areas. Traffic and pedestrian volumes on 109 Street are sufficient to warrant the installation of pedestrian crosswalk signals. The 109 Street location is one in which the vehicle signals were coordinated and had the same cycle time with the pedestrian signal randomly activated and using a base cycle time different than that of the up and down stream signals.

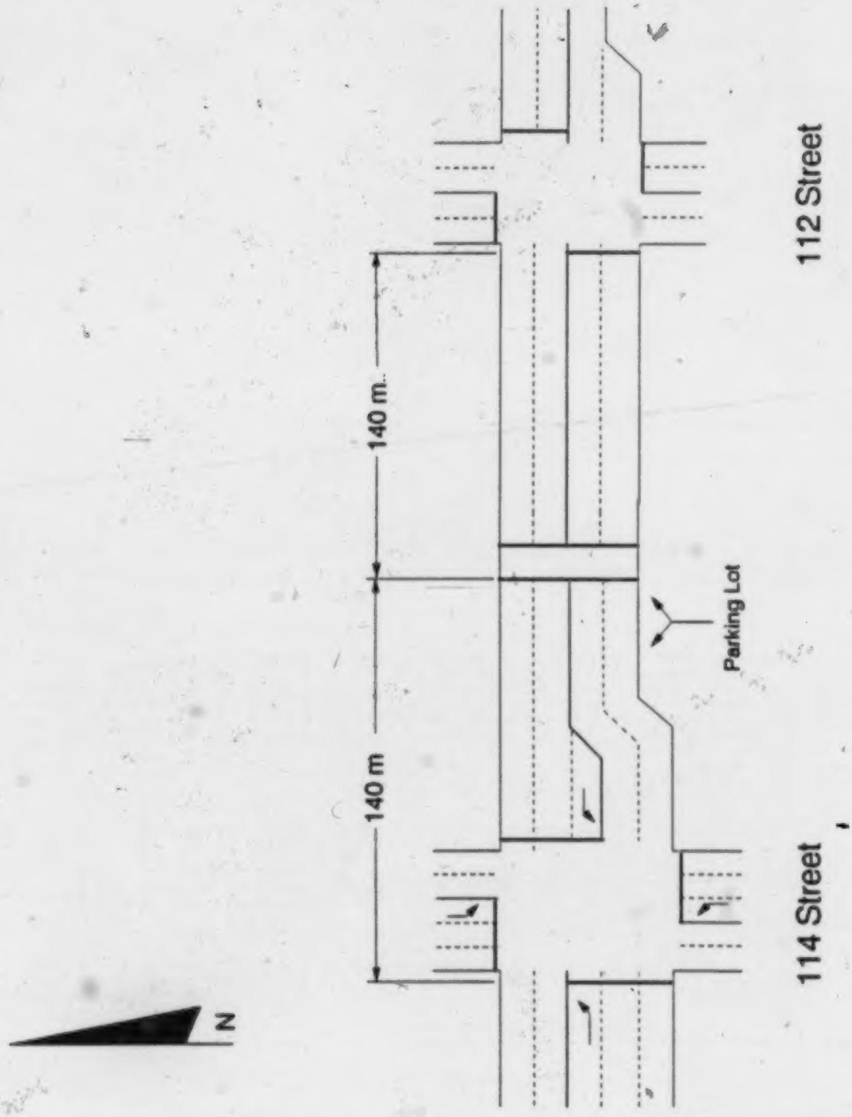

112 Street
140 m.
Parking Lot
140 m
114 Street
N

FIGURE 7.1

87 AVENUE FROM 112 STREET TO 114 STREET

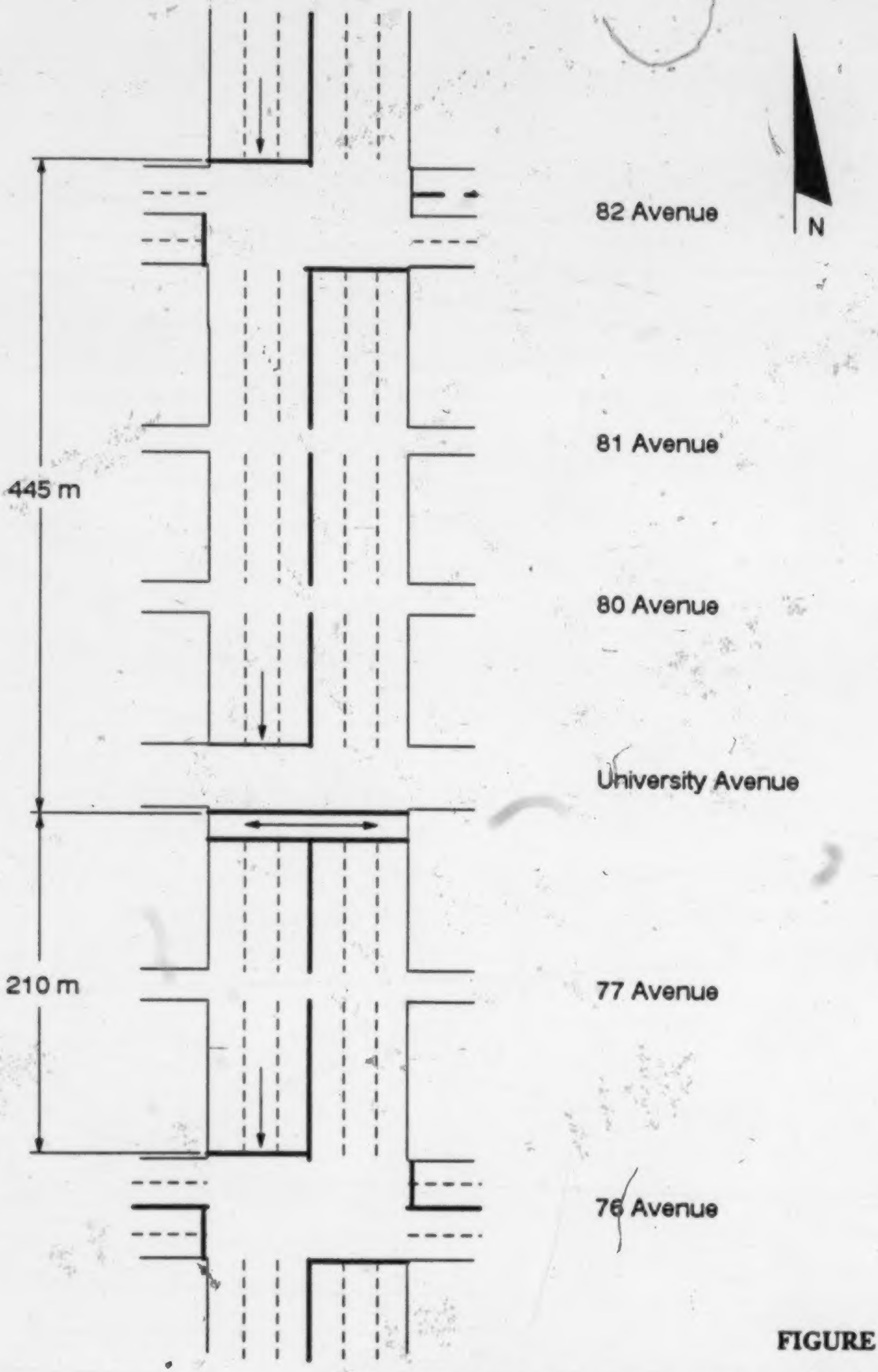

82 Avenue
N
81 Avenue
445 m
80 Avenue
University Avenue
210 m
77 Avenue
76 Avenue

FIGURE 7.2

109 STREET FROM 76 AVENUE TO 82 AVENUE

The traffic signals at both survey locations are under the control of central traffic control computer. The signals operate under a fixed-time, coordinated plan. The phasing diagrams and associated timings for both locations are illustrated in Figure 7.3.

At the 87 Avenue survey location there is a four phase traffic signal plan for the signals located at the intersection of 114 Street and 87 Avenue. Phase 1 allows all eastbound and westbound movements, phase 2 allows only the northbound movements, phase 3 allows the northbound and southbound movements and phase 4 allows only the westbound movements. The mid-block pedestrian crossing traffic signal is a two phase signal. Phase 1 allows the vehicle traffic to move freely and phase 2 allows the pedestrians to cross the roadway. The traffic signals at the intersection of 112 Street and 87 Avenue have a two phase signal plan with phase 1 allowing the northbound and southbound movements and phase 2 the eastbound and westbound movements.

At the 109 Street location there is a two phase signal plan for the traffic signal at the intersection of 109 Street and 82 Avenue. Phase 1 allows the north-south movements and phase two allows the east-west movements. The pedestrian crosswalk is also has a two phase signal plan with Phase 1 allowing the north-south vehicle movements and Phase 2 allowing the east-west pedestrian movements. The intersection of 76 Avenue and 109 Street also has a two phase signal plan with Phase 1 for the east-west movements and phase 2 for the north-south movements.

7.2.2 Methodology

87 Avenue

The data collection program occurred over three separate days. The original plan was to collect the data on two dates, on the first date the vehicle delay information would be collected and on the second date the pedestrian delay data would be collected.

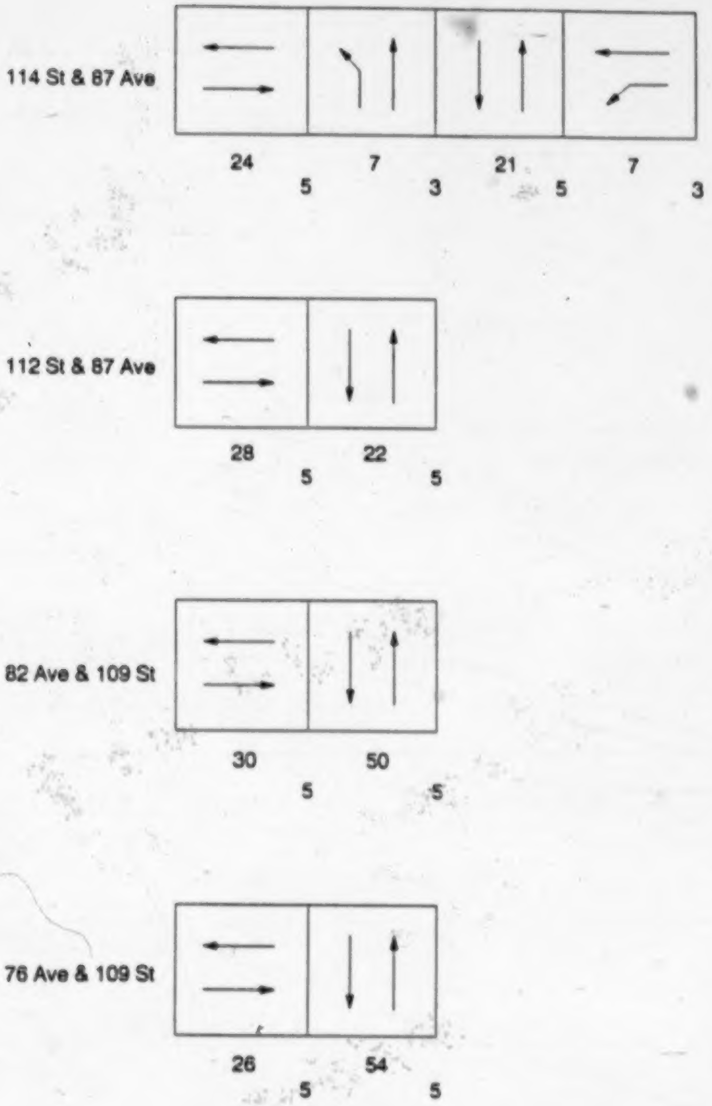

114 St & 87 Ave
24
5
7
3
21
5
7
3
112 St & 87 Ave
28
5
22
5
82 Ave & 109 St
30
5
50
5
76 Ave & 109 St
26
5
54
5

FIGURE 7.3

SIGNAL PHASING DIAGRAMS

Three individuals, including the author, were used in the data collection program. One person was stationed at each intersection and the pedestrian crossing to record the data. Each person recorded the number of vehicles stopped at the intersection approach at successive 15 second intervals. Vehicles could be counted more than once for as long as the vehicle remained queued at the intersection. A separate tabulation of the approach volume was made for each time period with the vehicles being further classified as being either stopped or not stopped. The data collection methodology and forms were obtained from the "Manual of Traffic Engineering Studies"[22].

The vehicle data collection program took place on April 15, 1991 between 13:15 and 13:45 (off-peak period).

After examining the collected data, it was discovered that the observer at 114 Street collected data for the westbound traffic stream at rather than the eastbound traffic stream. Therefore the author resurveyed the 114 Street intersection on April 17, 1991. The pedestrian data collection occurred on April 22, 1991.

At the intersection of 114 Street and 87 Avenue the inside eastbound traffic lane was surveyed. The curb lane was not selected because of the large number of right turning vehicles in this lane. A number of vehicles in the curb lane did, however, proceed straight through the intersection.

At the pedestrian crosswalk and the intersection of 112 Street and 87 Avenue both of the eastbound travel lanes were surveyed. Both lanes were surveyed to account for on-turning vehicles at the upstream location as well as to account for those vehicles that changed lanes once they discharged from the stopline at 114 Street.

All of the surveys occurred after the completion of the academic term at the University of Alberta. Students were still on campus preparing for and writing final examinations such that there was a sufficient volume of pedestrian and vehicle traffic.

109 Street

The data collection program occurred over two days with the vehicle traffic data being collected between 15:45 and 16:15 on Tuesday May 21, 1991 and the pedestrian data on Thursday May 23, 1991. The time period coincided with the beginning of the PM peak period. The southbound centre lane was surveyed at each intersection and the pedestrian crossing. The inside lane was not selected because of the large number of left turning vehicles and the curb lane was not selected because of the large number of buses and right turning vehicles which would impede the flow of through traffic.

The traffic signal timing plans were provided by the City of Edmonton Transportation Department.

7.2.3 Results and Analysis

The delay surveys for 87 Avenue yielded the following results:

- Average delay per approach vehicle at 114 Street and 87 Avenue: 13 seconds
- Average delay per approach vehicle at pedestrian crosswalk: 7 seconds
- Average delay per approach vehicle at 112 Street and 87 Avenue: 13 seconds
- Average delay per approach pedestrian: 15 seconds

The pedestrians exhibited a number of interesting characteristics during the delay survey. Of the total of 74 pedestrians, 9 pedestrians or 12 percent of the pedestrians violated the signal. In one instance when pedestrians were queued at the crosswalk, two other pedestrians approached the crossing, evaluated the traffic conditions and crossed against the signal. The persons who were originally queued at the crosswalk remained, even though two pedestrians crossed.

The delay surveys for the 109 Street location yielded the following results:

- Average delay per approach vehicle at 109 Street and 82 Avenue: 15 seconds

- Average delay per approach vehicle at pedestrian crosswalk: 5 seconds

- Average delay per approach vehicle at 109 Street and 76 Avenue: 6 seconds

- Average delay per approach pedestrian: 15 seconds

The relative percentages of vehicles stopped at each signal varied: 62 percent at 82 Avenue, 17 percent at the pedestrian crosswalk and 35 percent at 76 Avenue. The percentage of stopped vehicles was significantly lower at 76 Avenue and the average delay per vehicle was also much lower than that at 82 Avenue. For the pedestrians, the percentage stopped was 70 percent.

7.3 DELAY SURVEYS

The delay survey can be a useful tool when evaluating the operation of a traffic signal. Delay, as indicated in the Canadian Capacity Guide for Signalized Intersections and the Highway Capacity Manual, provides an estimate of the overall Level of Service being provided by the intersection. The difficulty with the determination of delay is that there are a number of different methods by which data may be collected.

Recently, Teply[17] discussed the accuracy of delay surveys at signalized intersections. In this paper, he assessed the merits of delay determination using a reconstructed time-space diagram, and using a queuing diagram. As well, he examined two different queue counts surveys, one counting the queues at regular intervals out of step with the signal and the other counting queues at the end of the red and green intervals. Teply concluded that delay cannot be precisely measured and that as a consequence a perfect match between an analytical delay formula and measured delay values is rarely attained.

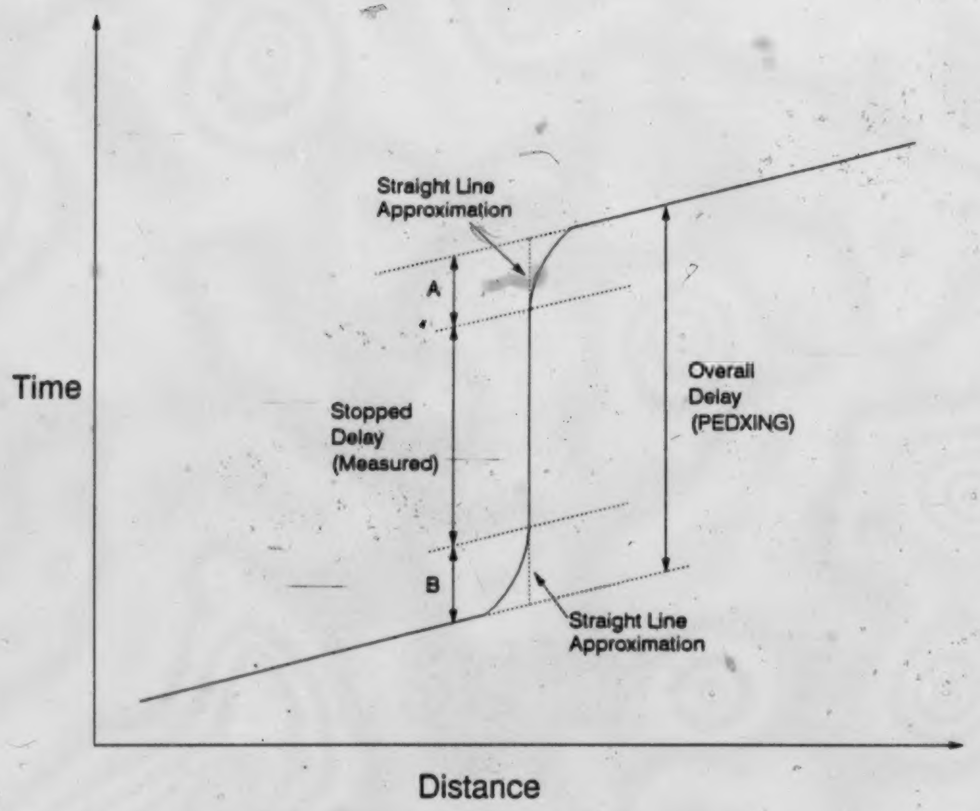
Some of the more important findings of Teply include:

- "delay surveys based on stopped queue counts produce stopped delay values.
- the ratio between overall delay and stopped delay is not constant and depends mostly on the duration of the red interval and on the volume-to-saturation ratio.
- the true ratio lies between the values obtained from using each formula."[17]

As illustrated by Teply, the use of delay as a measure of the quality of the operation of an intersection is useful and appropriate providing the analysis is performed in a consistent manner.

The delay surveys yielded values for the stopped delay while the PEDXING program yields overall delay due to the straight line approximation of the vehicle trajectories. The difference between stopped delay and overall delay is illustrated in Figure 7.4. The PEDXING program has no consideration for the impact of acceleration (denoted A on the figure) and deceleration (denoted B on the figure) and therefore the results are not directly comparable to delay values obtained from field queue counts.

The equations developed by Teply, as described in section 3.3.2, can be used to compare the results of model and the field data.


Straight Line Approximation
A
Time
Stopped Delay (Measured)
Overall Delay (PEDXING)
B
Straight Line Approximation
Distance

A = acceleration delay
B = deceleration delay

FIGURE 7.4

STOPPED AND OVERALL DELAY

8.0 COMPARISON OF FIELD AND MODEL DATA

Section 8.0 provides a discussion of the similarities and differences between the field data and the model output.

8.1 INTRODUCTION

In order to validate the results of any model, the model output must be compared to "real world" data. The data collected, as described in Section 7.0, has been compared to the model output, the results of which are presented below.

8.2 MODEL INPUT

The model was run using two data sets: one for the 87 Avenue location and one for the 109 Street location. Modelling each of these locations provides a comparison of field data to modelled data for both a coordinated and uncoordinated set of traffic signals. The input data are listed in Table 8.1.

TABLE 8.1
MODEL VERIFICATION INPUT DATA

	87 Avenue	109 Street
Through traffic volume (pcu/h)	185.	650.
Side street on turn traffic volume	130.	120.
Stopline saturation flow (pcu/h gr)	1550.	1750.
Duration of simulation (minutes)	60	60
Seed Number (odd three digit)	815	815
Vehicle Red Interval #1 (seconds)	51.	40.
Vehicle Green Interval #1 (seconds)	24.	50.
Vehicle Red Interval #2 (seconds)	32.	36.
Vehicle Green Interval #2 (seconds)	28.	54.
Pedestrian volume (peds/h)	150	50
Pedestrian WALK interval (seconds)	8	8
Pedestrian clearance period (seconds)	17	26
Travel time (Int.1 to ped crossing, seconds)	10	32
Travel time (Ped crossing to Int.2, seconds)	10	15
Signal Offset (seconds)	37	43
Intersection #1 cycle time (seconds)	75	90
Intersection #2 cycle time (seconds)	60	90
Minimum vehicle green interval at ped X-ing (sec)	40	45
PEDXING coordinated with signals (Y/N)	N	N
Print the Time Space Diagram (Y/N)	N	N
Produce detailed report	Y	Y

8.2.1 87 AVENUE LOCATION

For this location the program was run with the mid-block pedestrian crossing uncoordinated with the upstream traffic signal. The cycle time at the 114 Street intersection was 75 seconds, at the mid-block pedestrian crossing, 65 seconds, and at the 112 Street intersection 60 seconds, during the off-peak period. The 6 second vehicle intergreen period for the mid-block crossing was accommodated in the pedestrian clearance interval.

8.2.2 109 Street Location

The program was run with the mid-block pedestrian crossing uncoordinated with the upstream traffic signal. The cycle time at both the 82 Avenue and 76 Avenue intersections was 90 seconds, and at the mid-block pedestrian crossing 79 seconds during the PM peak period. The six second vehicle intergreen period for the mid-block crossing was accommodated in the pedestrian clearance interval.

A slightly reduced through volume and a saturation flow rate of 1750 pcu/h gr was used in order to allow the model to run. The model checks to ensure that the V/C ratio is below 0.80. The actual volume was in the order of 800 vph but that volume, in conjunction with the sidestreet volume would exceed the maximum allowable V/C ratio. Therefore the through volume was reduced from 800 vph to 650 vph.

8.3 MODEL OUTPUT

The average vehicle delay for intersection #1 is calculated using only the through vehicles, i.e. the on-turning vehicles have not been included. It is assumed that the on-turning vehicles were not delayed by the traffic signal. Using only the through vehicles allows for a comparison between the measured delay and modelled delay since only the through vehicles are surveyed in the field. It is for this reason that the individual average intersection delays do not sum to the final average total vehicle delay.

8.3.1 87 Avenue Location

This location was completely uncoordinated with all three signals having different cycle times. The PEDXING program was run eight times, each with a different random seed number. The results illustrated in Table 8.2, are the average values of the runs:

TABLE 8.2

87 Avenue Average Model Results

114 Street and 87 Avenue (Int. #1) Average Intersection Vehicle Delay	=	20.0 sec
Average Ped. Delay	=	23.4 sec
Mid-block Pedestrian Crossing Average Intersection Vehicle Delay	=	5.0 sec
112 Street and 87 Avenue (Int. #2) Average Intersection Vehicle Delay	=	10.5 sec

As expected, the vehicle delays are highest at the intersections and lowest at the pedestrian crossing, with a vehicle red interval of only 25 seconds at the pedestrian crossing.

8.3.2 109 Street Location

At this location the 82 Avenue and 76 Avenue signals were coordinated, each having a 90 second cycle time. The mid-block crossing was not coordinated with either of the other signals. The PEDXING program was run eight times, each with a different random seed number. The results illustrated in Table 8.3 are the average values of the runs.

TABLE 8.3

109 Street Average Model Results

82 Avenue and 109 Street (Int. #1) Average Intersection Vehicle Delay	= 13.0 sec
Average Ped. Delay	= 20.0 sec
Mid-block Pedestrian Crossing Average Intersection Vehicle Delay	= 9.0 sec
76 Avenue and 109 Street (Int. #2) Average Intersection Vehicle Delay	= 10.0 sec

As expected, the vehicle delays are highest at the intersection and lowest at the pedestrian crossing, with a vehicle red interval of only 25 seconds at the pedestrian crossing.

8.4 87 AVENUE LOCATION COMPARISON

Table 8.4 illustrates the differences between the modelled and the observed delays.

TABLE 8.4

87 Avenue Delay Comparison

	Modeled	Observed
114 Street and 87 Avenue (Int. #1) Average Intersection Vehicle Delay	20.0 sec	13.0 sec
Average Pedestrian Delay	23.4 sec	15.0 sec
Mid-block Pedestrian Crossing Average Intersection Vehicle Delay	5.0 sec	7.0 sec
112 Street and 87 Avenue (Int. #2) Average Intersection Vehicle Delay	11.0 sec	13.0 sec

8.4.1 114 Street and 87 Avenue

The model output yielded an average vehicle delay of 20 seconds as compared to a measured delay of 13 seconds. The models overestimation of the delay is due to a number of factors including the arrival distribution used. The model uses a shifted negative exponential distribution for the arrival headways, implying a random arrival pattern. Located upstream of the 114 Street intersection is a randomly activated, uncoordinated mid-block pedestrian signal, an amber-flash pedestrian crossing and full traffic signal. These three traffic control devices tend to cause the vehicle arrivals to be non-random for some signal cycles.

Figure 8.1 illustrates the observed, theoretical and modelled arrival headway probabilities.

This arrival non-randomness can cause the measured delay to be either less than or greater than the modelled delay depending on when the discharged vehicles arrive at the signal. For example if the signal(s) upstream of the 114 Street signal are directly out of step with the 114 Street signal, most of the vehicles will arrive during the red interval. If the upstream signals are only partially out of step with the 114 Street signal then a portion of the vehicle platoon will arrive during the red interval and a portion will arrive during the green interval (similar to random arrival).

The influence of the upstream signals also extends to the impact of platooning. The arrival pattern used in the model assumes that there is no vehicle platooning such that the vehicle arrival headways are random. The presence of upstream traffic signals will cause the vehicles to platoon and thereby have a regular arrival rate, possibly at the saturation flow values.

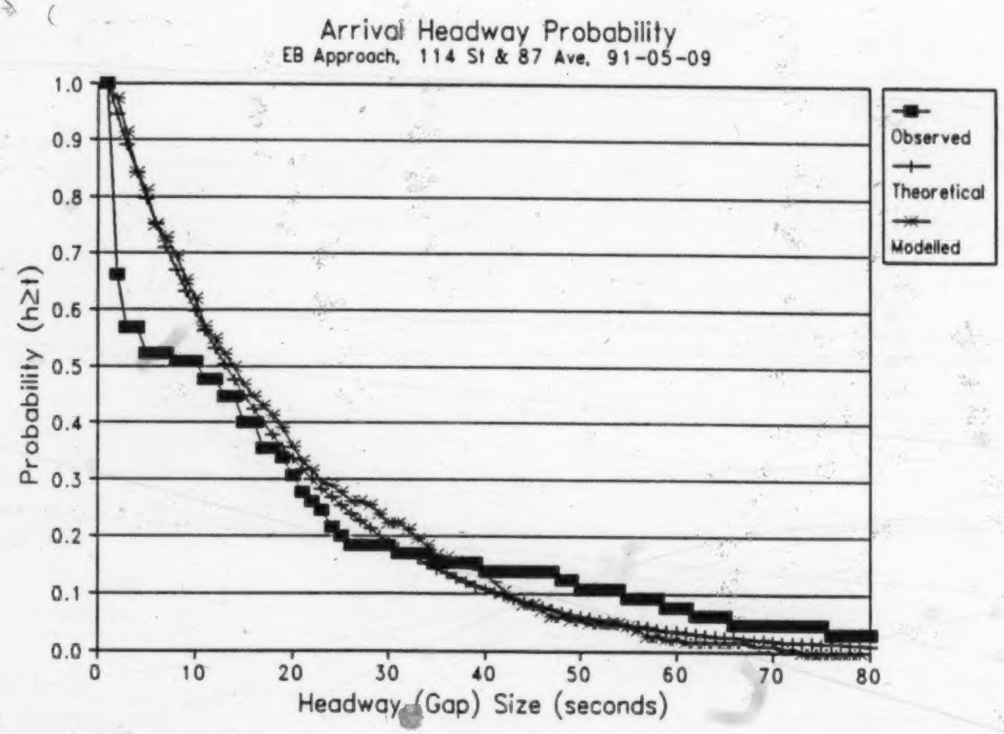


FIGURE 8.1

ARRIVAL HEADWAY PROBABILITY FOR 114 ST AND 87 AVE EASTBOUND THROUGH MOVEMENT (INTERSECTION #1)

According to the model, (illustrated in Figure 8.2) approximately 55 percent of the vehicles travelling through the 114 Street intersection were delayed to some degree. This compares to an observed value of 51 percent. If the arrival pattern is truly random, it would be expected that approximately 50 percent of the vehicles would be delayed by the intersection. In addition, the green interval comprises approximately 32 percent of the total cycle time such that if the arrival pattern was truly random with an equal number of vehicles arriving during any given time interval, it would be expected that 68 percent of the vehicles would experience some degree of delay. The percentage of delayed vehicles observed in the field (51 percent) illustrates that the arrival pattern is not truly random.

The difference between the modelled vehicle delay and the observed delay is not considered to reflect below average operation of the model. The difference in the arrival distributions was one of the primary reasons for the difference between the observed and the modelled delay values.

8.4.2 Mid-block Pedestrian Crossing

There are two delay values calculated for the pedestrian crossing: average pedestrian delay and average vehicle delay. The modelled average pedestrian delay was 23.4 seconds as compared to an observed average pedestrian delay of 15 seconds. The modelled average vehicle delay was 5 seconds as compared to an observed average vehicle delay of 7 seconds.

The difference between the modelled average pedestrian delay and the observed average pedestrian delay was 9 seconds. One reason for the overestimation of the pedestrian delay was that the model predicted that 85 percent of the pedestrians would be delayed (illustrated in Figure 8.3) as opposed to an observed value of 64 percent. Since the model overestimated the number of delayed pedestrians, the average delay per pedestrian also is overestimated.

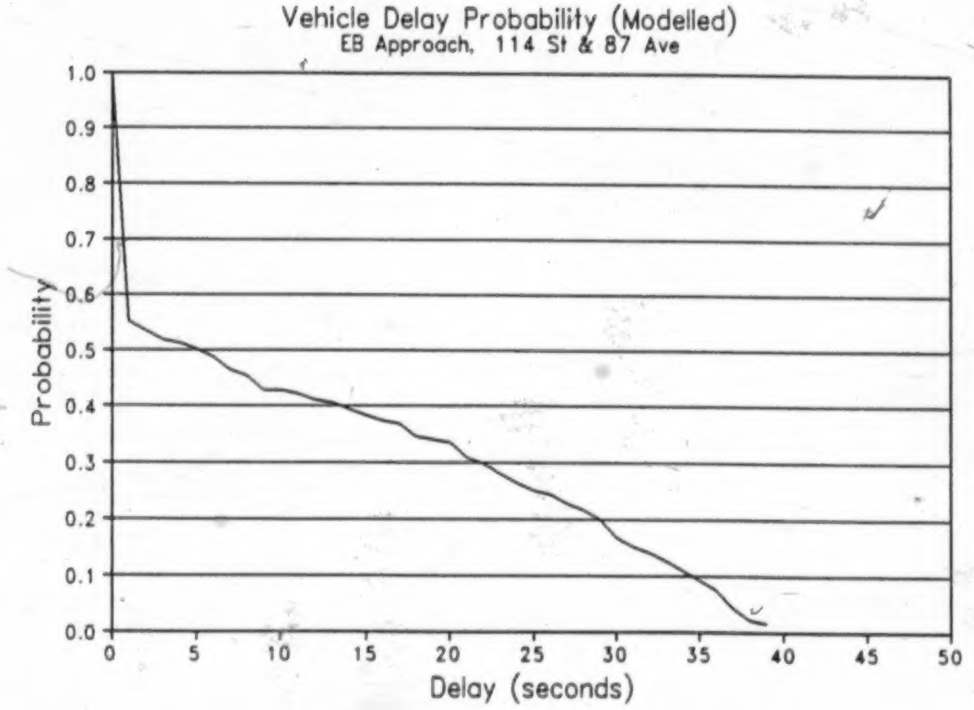


FIGURE 8.2

**MODELLED VEHICLE DELAY PROBABILITY
INTERSECTION OF 114 ST AND 87 AVE
EASTBOUND THROUGH MOVEMENT (INTERSECTION #1)**

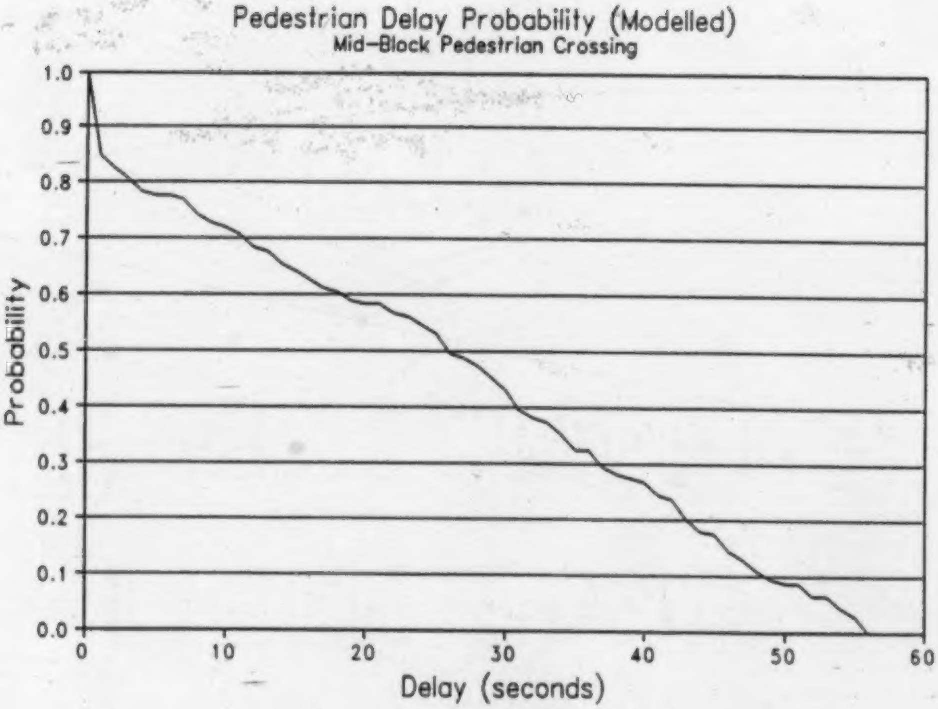


FIGURE 8.3

MODELLED PEDESTRIAN DELAY PROBABILITY
87 AVENUE MID-BLOCK CROSSING

The model also tended to overestimate the size of the pedestrian departure groups at the crosswalk, as illustrated in Figure 8.4. The model predicted 18 individual pedestrians arriving and discharging through the crosswalk as compared to the 8 observed. The model was reasonably accurate projecting the number of discharge group sizes between quantities of 2 through 5. Interestingly the model projected that there would be discharge groups having 6 and 7 persons yet no groups of this size were observed.

To illustrate the impact of the over-estimation of the number of delayed pedestrians the following is presented. The model passed 135 pedestrians through the crosswalk during the simulated one hour period. Fifteen percent of 135 is 20 pedestrians, and 36 percent of 135 is 49 pedestrians. The total pedestrian delay is 3,159 seconds (135 x 23.4). If 679 seconds are removed from the total, ([49 - 20] * 23.4), the remainder is 2,480 seconds. Dividing this revised total delay by 135, yields an average delay of 18.4 seconds. This average delay is much closer to the observed 15 seconds. Given that the observation interval for the field study was 15 seconds, the model results - raw or modified, yield a reasonable estimation of the pedestrian delay.

The modelled average vehicle delay was close to the observed value. Given that there was amber overrun by vehicles, the difference could be reduced by lengthening the green interval to phase green plus one or two seconds. The increase in the duration of the green interval could result in additional vehicles passing through the pedestrian signal rather than being stopped by the signal, thereby reducing the overall average vehicle delay. Figure 8.5 illustrates the modelled vehicle delay probability. As indicated, approximately 40 percent of the vehicles experienced delays of at least one second. The results of the field survey yielded that 38 percent of the vehicles were delayed. The similarity between the two percentages is reflected in the small difference between the modelled and the observed vehicle delay for this intersection.

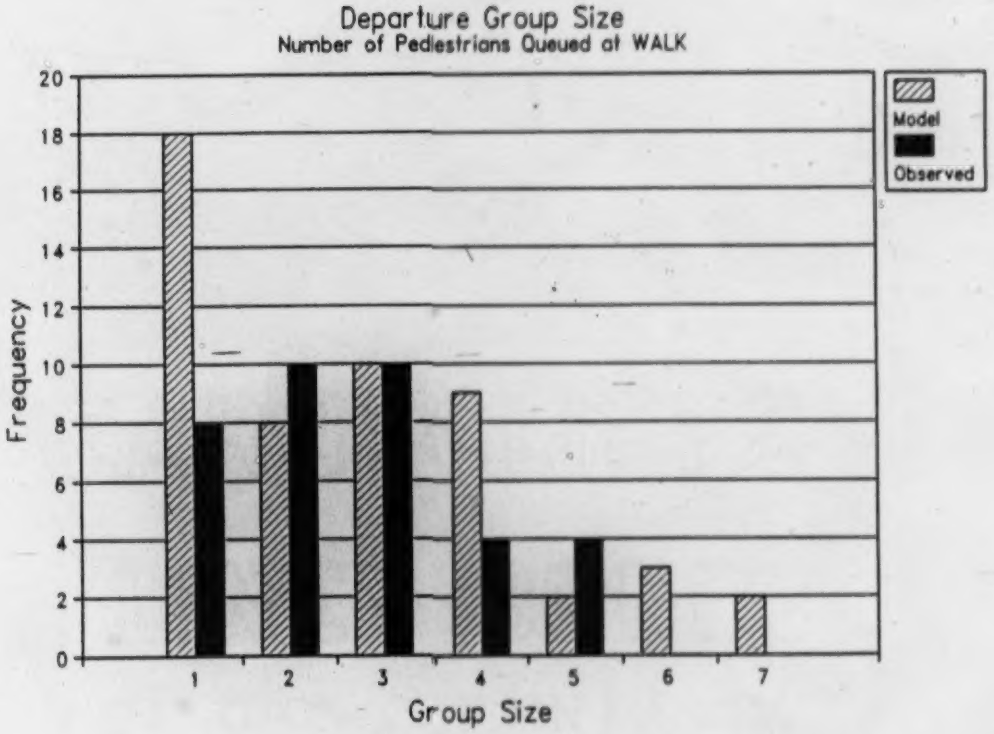


FIGURE 8.4

MODELLED PEDESTRIAN GROUP SIZE
87 AVENUE MID-BLOCK PEDESTRIAN CROSSING

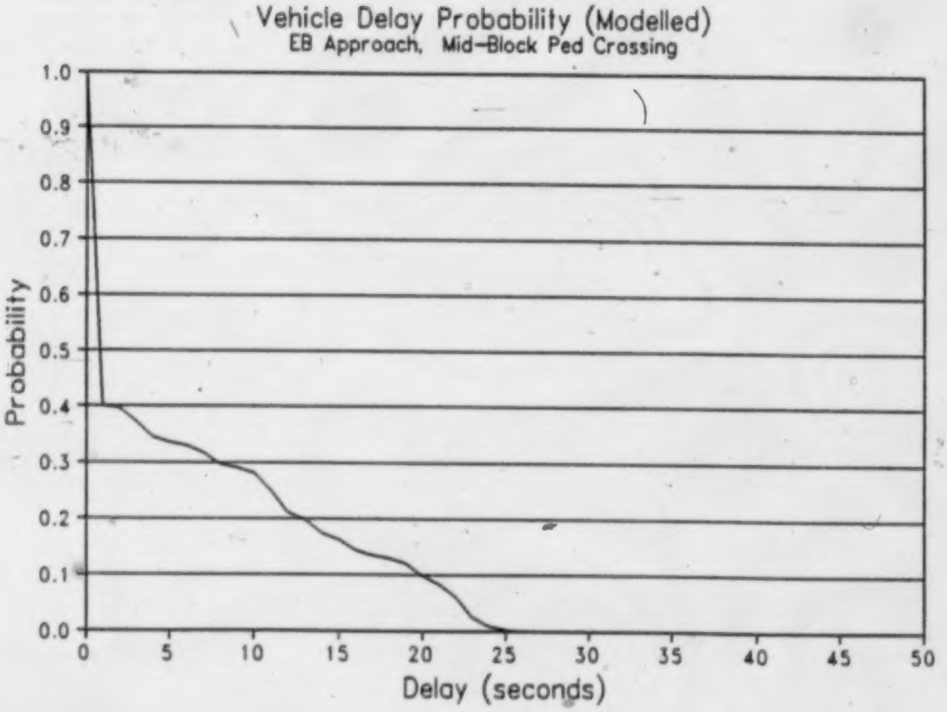


FIGURE 8.5

**MODELLED VEHICLE DELAY PROBABILITY
87 AVE MID-BLOCK PEDESTRIAN CROSSING
EASTBOUND THROUGH MOVEMENT**

8.4.3 112 Street and 87 Avenue

The modelled average vehicle delay for this intersection was 11 seconds which compares favourably to the observed value of 13 seconds. According to the model 63 percent of the vehicles experienced delay at this intersection as compared to an observed value of 47 percent. It would be expected that with the higher probability of delay, the model would overestimate the average delay, but as illustrated in Figure 8.6, 50 percent of the modelled vehicles experienced delays of less than 10 seconds. This leads to the conclusion that although less vehicles are delayed in the field than in the model, the field vehicles are delayed for much longer periods of time, i.e. they arrive at the beginning of the red interval.

8.5 109 STREET LOCATION COMPARISON

Table 8.5 illustrates the differences between the modelled and the observed values of delay.

TABLE 8.5

109 Street Delay Comparison

	Modelled	Observed
82 Avenue and 109 Street (Int. #1) Average Intersection Vehicle Delay	13.0 sec	15.0 sec
Average Pedestrian Delay	20.0 sec	15.0 sec
Mid-block Pedestrian Crossing Average Intersection Vehicle Delay	9.0 sec	5.0 sec
76 Avenue and 109 Street (Int. #2) Average Intersection Vehicle Delay	10.0 sec	6.0 sec

As illustrated by the table, the modelled delay values are close to the values observed in the field.

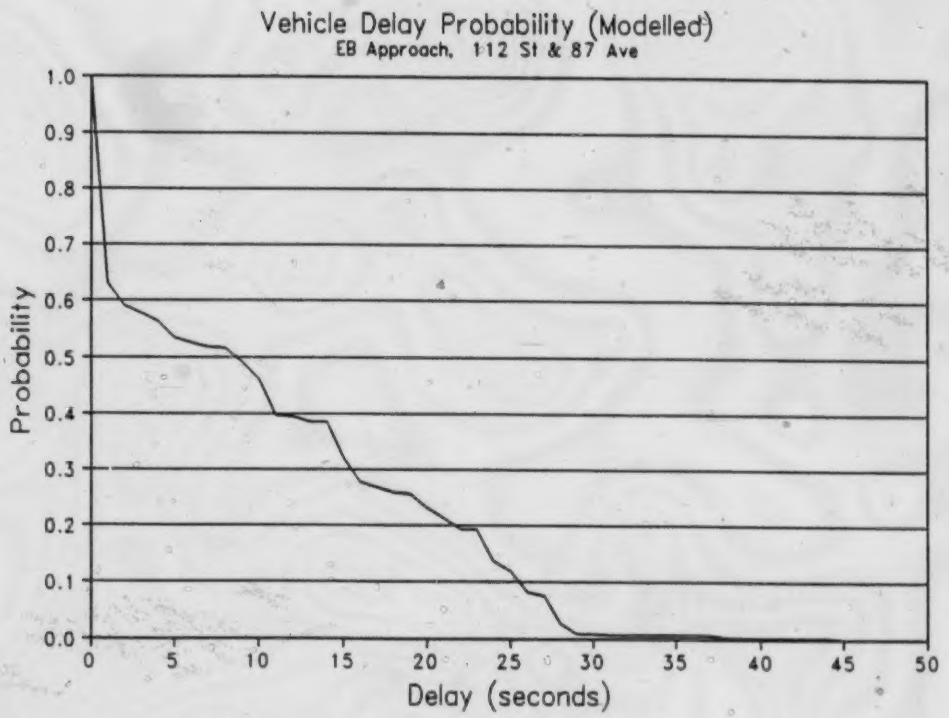


FIGURE 8.6

MODELLED VEHICLE DELAY PROBABILITY
INTERSECTION OF 112 ST AND 87 AVE
EASTBOUND TRHOUGH MOVEMENT

8.5.1 82 Avenue and 109 Street

The modelled average vehicle delay is within 2 seconds of the observed value, a closer match than that of the 87 Avenue location. This match can be attributed to the modelled versus the observed arrival patterns. As illustrated in Figure 8.7, the observed, theoretical and modelled arrival headway probabilities are similar. The modelled arrival headway probability is shifted to the right slightly, nonetheless the modelled delays match the observed closely.

The model predicted that 63 percent of the vehicles would be delayed (as illustrated in Figure 8.8) as compared to the observed 62 percent. This similarity between the two values aids in the explanation of the similarity between the modelled and observed average vehicle delays. If the percentages were significantly different then it would be expected that the delays would also be quite different.

Unlike the 114 Street intersection in the 87 Avenue study, the majority of the cycle time is devoted to the study movement (southbound) through the intersection, i.e. the green interval accounts for 56 percent of the cycle time. The number of delayed vehicles is relatively high due to the significantly higher volume passing through the intersection. With the majority of the green interval, it would be expected that most of the vehicles arriving at the intersection would be undelayed, but because of the large volume, the queues require a significant portion of the green interval to discharge.

8.5.2 University Avenue and 109 Street

The model predicted an average vehicle delay of 9.0 seconds versus the observed 5.0 seconds and an average pedestrian delay of 20 seconds versus the observed 15.0 seconds. The difference between the actual and the modelled delay in both cases can be explained by the operation of the pedestrian signal.

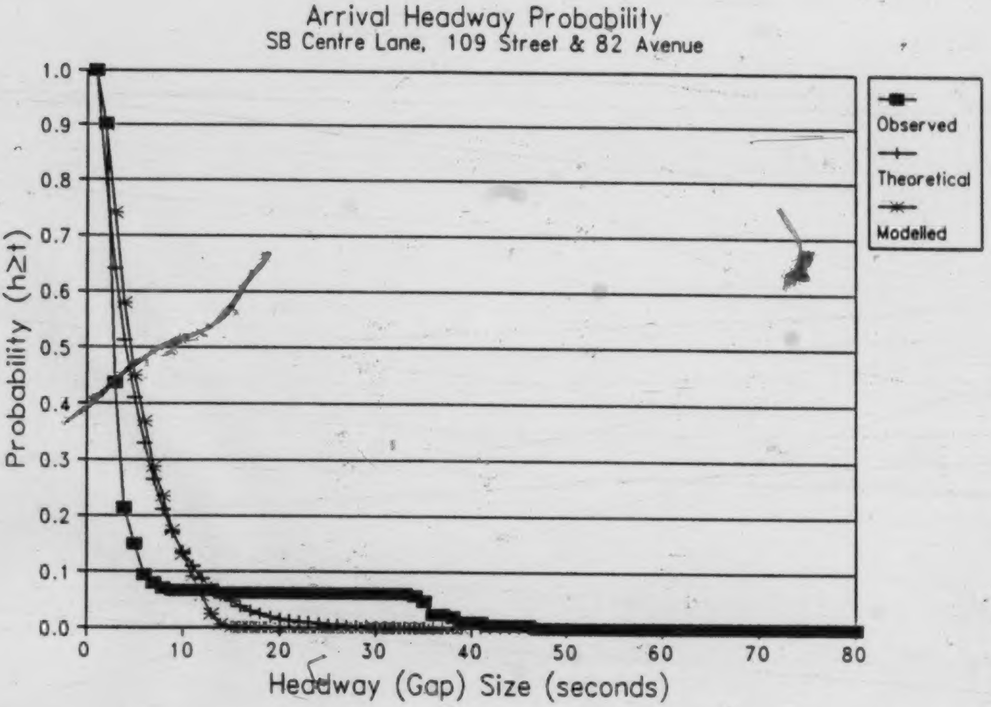


FIGURE 8.7

ARRIVAL HEADWAY PROBABILITY FOR ~~82 AVE~~ AND 109 ST SOUTHBOUND THROUGH MOVEMENT (INTERSECTION #1)

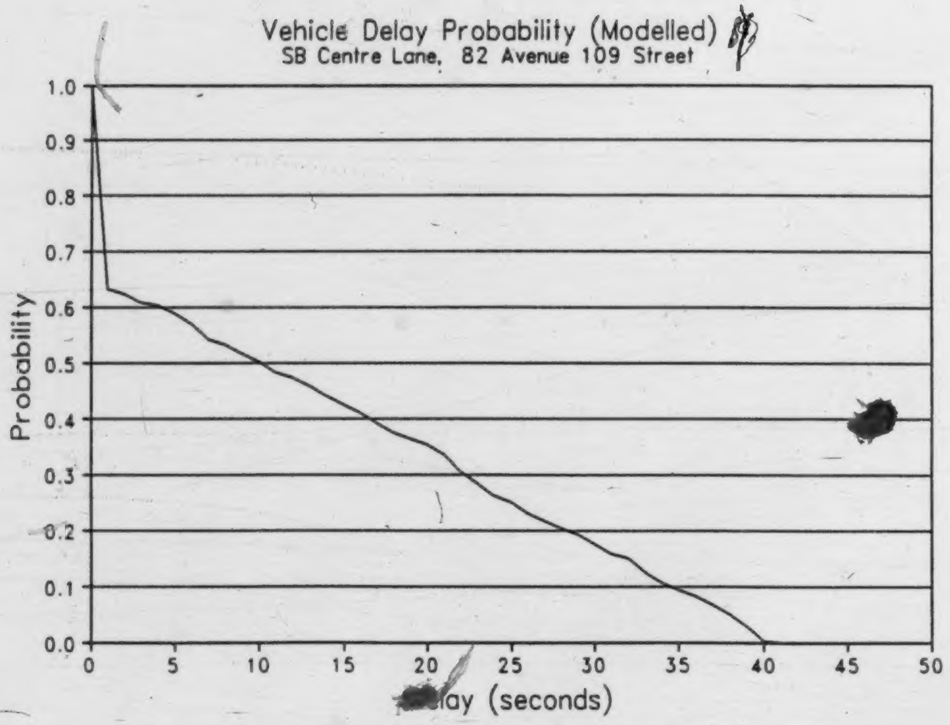


FIGURE 8.8

MODELLED VEHICLE DELAY PROBABILITY
INTERSECTION OF 82 AVE AND 109 ST
SOUTHBOUND THROUGH MOVEMENT (INTERSECTION #1)

As illustrated in Figure 8.9, the model over-estimated the number of single pedestrian departure groups and did not predict any departure groups with more than three pedestrians. The pedestrian volume at the crosswalk was light, only 50 pedestrian per hour as compared to the volume of 150 pedestrians per hour at the 87 Avenue crosswalk.

The model also predicted that 60 percent of the pedestrians would be delayed by the crosswalk (illustrated in Figure 8.10) as compared to the observed 70 percent. The probability of being delayed was lower for the model but the average delay was higher. The model over predicts the number of pedestrians arriving just after the completion of the WALK phase. When pedestrians arrive during the clearance period, the model does not allow them to cross and therefore they must wait for the remainder of the clearance phase plus the duration of the minimum vehicle green interval.

The model predicted that 50 percent of the vehicles at the mid-block crossing would be delayed (illustrated in Figure 8.11) as compared to the observed 17 percent. The primary reason for the overestimation of the percentage delayed is that the model predicted 30 signal activations as opposed to the observed 20 activations. If it is assumed that there is a linear relationship between the number of signal activations and the average vehicle delay, reducing the number of activations by one third would yield a reduction of the average vehicle delay of 3 seconds from 9 seconds to 6 seconds, close to the observed 5 seconds.

8.5.3 76 Avenue and 109 Street

The observed average vehicle delay was 6 seconds versus the modelled average vehicle delay of 10 seconds. As at the upstream traffic signals, the model predicted higher average vehicle delays, due in part to the percentage of vehicles that are delayed. In the field only 35 percent of the vehicles were delayed but the model predicted that 63 percent of the vehicles would be delayed, as illustrated in Figure 8.12. Despite the difference in the percentage of the traffic stream that is delayed, the modelled versus the observed delays are similar.

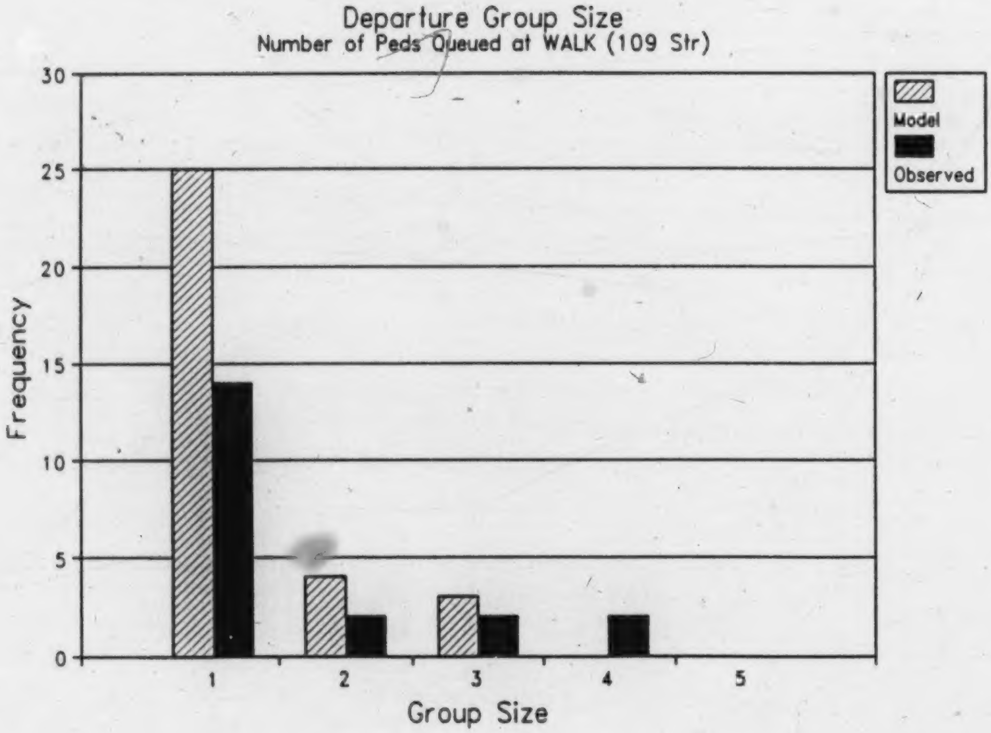


FIGURE 8.9

PEDESTRIAN DEPARTURE GROUP SIZE
109 STREET MID-BLOCK CROSSING

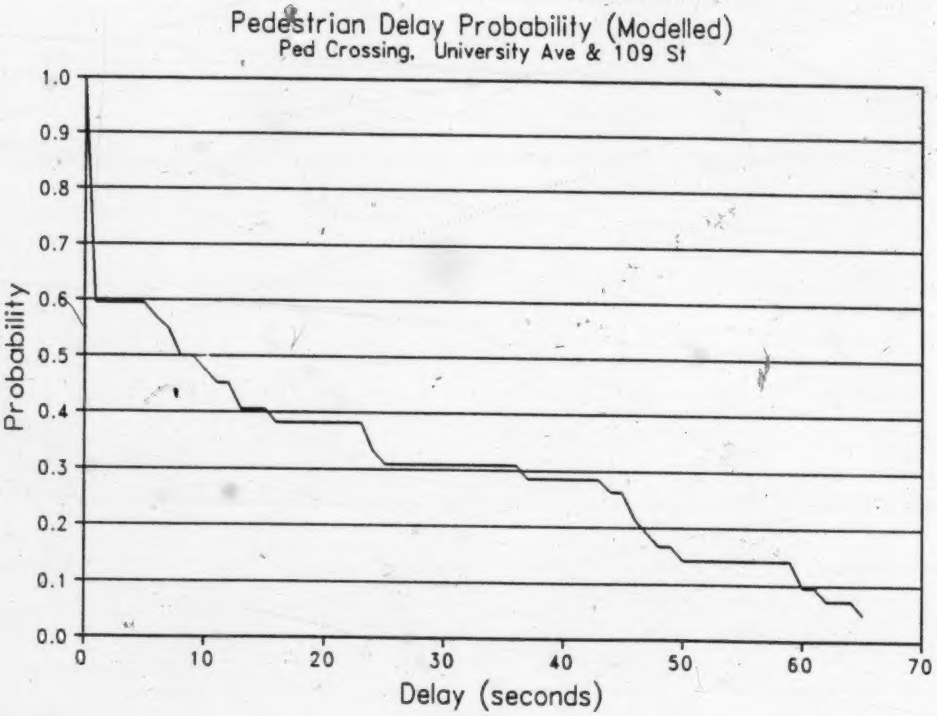


FIGURE 8.10

MODELLED PEDESTRIAN DELAY PROBABILITY
109 STREET MID-BLOCK CROSSING

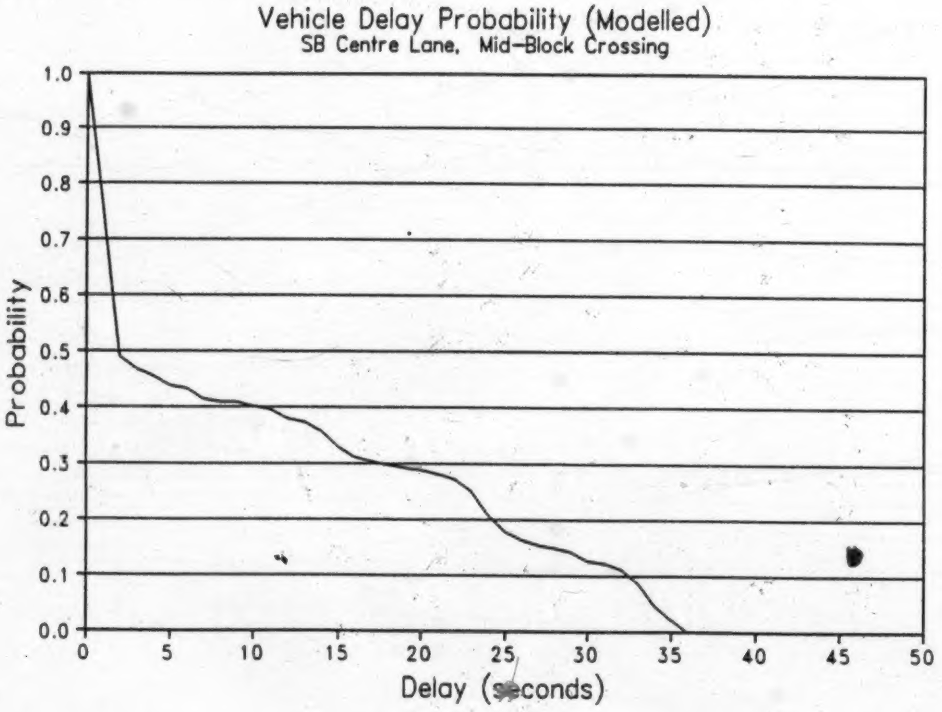


FIGURE 8.11

MODELLED VEHICLE DELAY PROBABILITY
109 STREET MID-BLOCK CROSSING
SOUTHBOUND THROUGH MOVEMENT

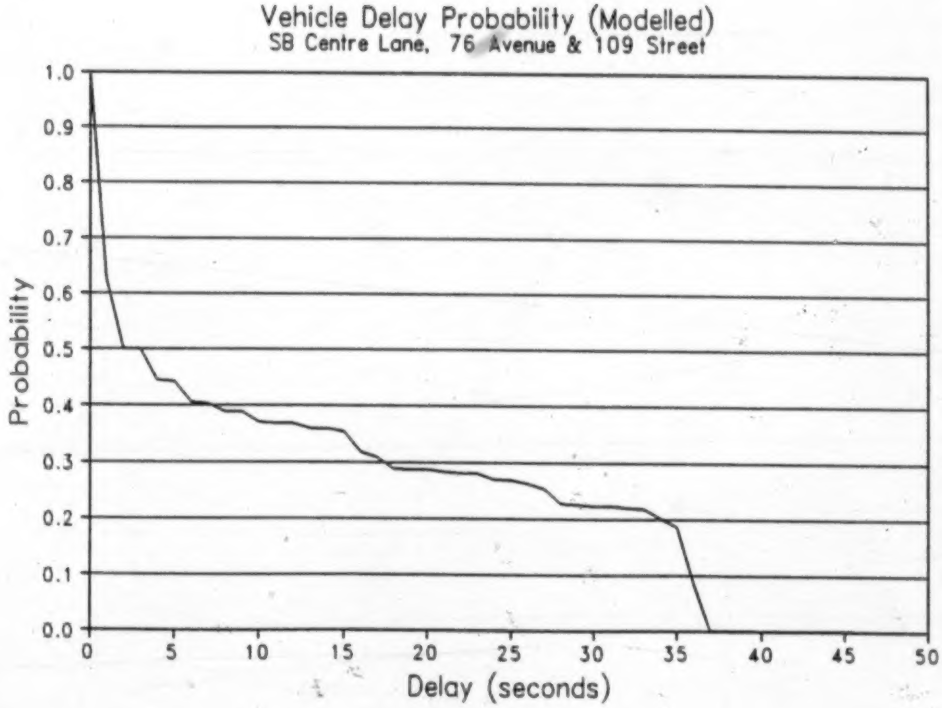


FIGURE 8.12

MODELLED VEHICLE DELAY PROBABILITY
INTERSECTION OF 76 AVE AND 109 ST
SOUTHBOUND THROUGH MOVEMENT

8.6 ANALYSIS OF DIFFERENCES

As noted in section 7.3, the model yields values for the overall delay while the survey data yields the stopped delay. The approximate value of the overall delay at each intersection can be determined using the two equations developed by Teply[17] to relate the stopped delay to the overall delay. The results of the equations are presented in Table 8.6, following:

TABLE 8.6
MODELLED, OBSERVED AND MODIFIED DELAYS

	Actual (Stopped)	Eqn. 3.1 (Overall)	Eqn. 3.2 (Overall)	Modelled (Overall)
114 Street and 87 Avenue	13.0	15.7	13.2	20.0
Mid-Block Pedestrian Crossing	7.0	9.6	7.1	5.0
112 Street and 87 Avenue	13.0	19.5	13.3	11.0
82 Avenue and 109 Street	15.0	19.2	17.4	13.0
University Avenue and 109 Street	5.0	6.6	6.2	9.0
76 Avenue and 109 Street	6.0	8.0	7.4	10.0

Figures 8.13 and 8.14 graphically illustrate the data listed in Table 8.6. The histogram for 87 Avenue uses a maximum Y-axis value of 50 seconds, equivalent to the duration of the red interval at the intersection of 114 Street and 87 Avenue. Similarly, the histogram for 109 Street has a maximum Y-axis value of 40 seconds, equivalent to the duration of the red interval at the intersection of 82 Avenue and 109 Street. The duration of the red interval was selected because it represents the maximum time that a vehicle can be delayed at a signal during under-saturated conditions. Using this value for the maximum presents the data in a format that indicates the differences at a scale relative to the maximum possible delay.

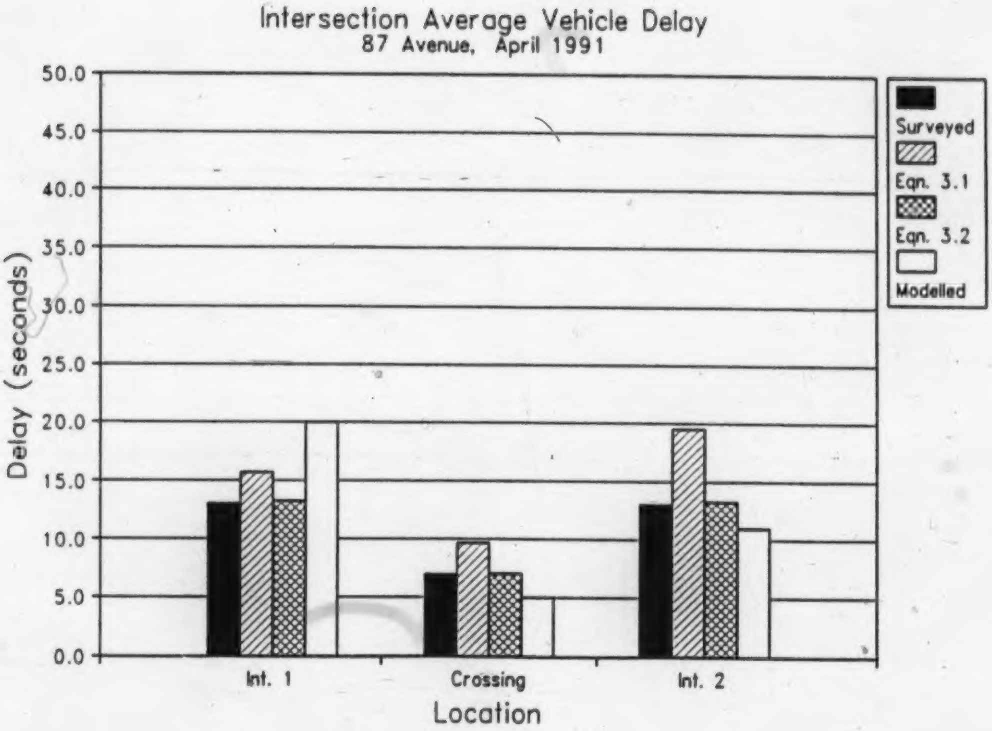


FIGURE 8.13

AVERAGE VEHICLE DELAY
87 AVENUE NETWORK
EASTBOUND THROUGH MOVEMENT

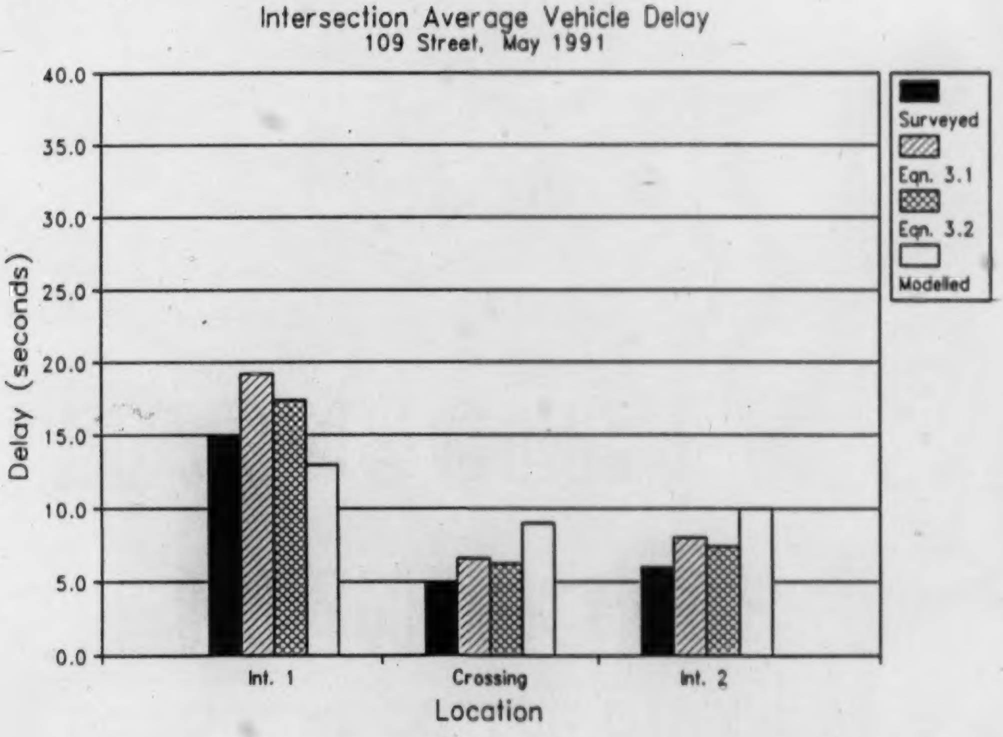


FIGURE 8.14

AVERAGE VEHICLE DELAY
109 STREET NETWORK
SOUTHBOUND THROUGH MOVEMENT

As illustrated by these Figures, the model yields results that are of the correct order of magnitude for the average vehicle delay at each intersection. The over- or underestimation of the average delay by the model is caused by a number of factors including the distances between the stoplines, the input volumes and the coordination of the system.

8.7 SUMMARY

The model was run using two test cases: an uncoordinated and a coordinated signal system. The model output closely resembled the observed values. Both the vehicle and the pedestrian delays determined by the model were of the correct order of magnitude.

9.0 CONCLUSIONS

Section 9.0 presents the summary and conclusions of this project as well as recommendations for further research.

9.1 CONCLUSIONS

The objective of this research was to develop a computer model to simulate a mid-block pedestrian signal within a fixed-time traffic signal system. This objective was met. The developed model, PEDXING, provides realistic estimates of the impact of a mid-block pedestrian traffic signal on both pedestrians and vehicles in terms of delay incurred by each. It is suitable for both coordinated and uncoordinated traffic signal systems and has the capability of modelling a variety of geometric and operational features.

The program was written in Microsoft FORTRAN 4.1 and was designed to operate in batch mode. The user prepares a small input data file and runs the program. Typically the program requires approximately 4 minutes to perform one complete run, using a 10 Mhz 80286 based PC. The program was written in a modular format to provide maximum flexibility for input, output and to allow future researchers to easily change the program source code.

The model was tested to ensure that the program processed information correctly. The model was verified by comparing the model output to the results of two survey locations. The output was in the correct order of magnitude for the average vehicle delay and pedestrian delay for each of the modelled intersections.

The program provides the transportation engineer with a tool that can be used to assess the impact of implementing a pedestrian traffic signal, in terms of delay. The model can also be used to assess the impact of including the pedestrian crossing traffic signal into the signal coordination. The program is intended for use in evaluating signalization and coordination policies within a Civic Transportation Department.

9.2 ADDITIONAL RESEARCH

As a direct result of the research conducted, a number of addition research needs have been identified:

9.2.1 Pedestrian Characteristics

Several pedestrian characteristics have been observed which will have a bearing on the operation of a pedestrian traffic signal and hence on the operation of the model. These characteristics include: the grouping/queuing of pedestrians at the signal as well as the arrival of groups of pedestrians at the signal; gap acceptance and signal obeyance of pedestrians; pedestrian risk exposure.

Each of these characteristics requires further study in order to establish quantifiable measures for each as well as to determine locational variations. The risk exposure behaviour of pedestrians encompasses gap acceptance and signal obeyance. In addition, more research is required to determine the variation of pedestrian behaviour according to age.

9.2.2 Program Enhancements

The PEDXING model could be modified to accept data from electronic recorders such as the University of Alberta Data Logger in order to more accurately represent the arrival pattern(s) of vehicles at the first traffic signal.

The model may also be enhanced to allow for the use of different headway distributions to be selected by the user. For example, for some locations it may be prudent to utilize a Hyperlang headway distribution model for the vehicle arrival pattern. Similarly, to account for pedestrians crossing during acceptable gaps the Erlang distribution could be used.

The model could also be enhanced to account for conditions when the V/C ratio exceeds 0.80 when the overflow delay becomes a key component of the total delay. Along with this enhancement, methodologies would have to be utilized to account for vehicle queue length and platoon dispersion for locations with long distances between signalized intersections.

9.2.3 Statistical Analysis

As the model is further refined to allow for pedestrian gap acceptance or vehicle disobeyance of the signals, a detailed statistical analysis of the variation of the field data collection in conjunction with a statistical analysis of the model output should be completed.

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APPENDIX A

```
$NOTRUNCATE
$DEBUG
C
C     PROGRAM PED-XING
C
C     NOTE: Do NOT remove the $NOTRUNCATE metacommand on line one of
C           this program.  This metacommand allows the program to use
C           variable names longer than six (6) characters.
C
C     This program is designed to generate random vehicle and pedestrian
C     arrivals into a one-way street system.  There are three signals on
C     the network: the first and third signals are either coordinated
C     or uncoordinated fixed time traffic signals.  The second signal is
C     a pedestrian activated or a fixed time signal (user discretion).
C     The program is designed such that the vehicles are randomly
C     generated and processed through the first intersection.  The
C     departure time and the delay incurred is stored in an array.
C
C     Then the pedestrian activations are randomly generated and
C     processed through the second intersection (signalized pedestrian
C     crossing).  Based on a background cycle for this intersection (ie.
C     minimum vehicle green, length of walk phase and pedestrian
C     clearance interval) the delay is calculated for each pedestrian
C     and again stored in an array.  The pedestrian activations in turn
C     cause the vehicle signal to change from green to red.  The time of
C     this change is stored in an array to be used when the vehicles are
C     processed through the second intersection.
C
C     Once the pedestrian activations and hence the red signals have
C     been determined the program processes the vehicles through the
C     second intersection.  The program determines the delay incurred by
C     each vehicle and adds the second intersection delay to the first
C     intersection delay as well as calculating the average vehicle
C     delay for this intersection.
C
C     The program then continues on to the third and final intersection
C     and determines the average vehicle delay at this intersection and
C     calculates the overall average vehicle delay.
C
C     The program adjusts the headway according to flow conditions:
C     heavy flow = small headways, light flow = large headways.  The
C     program also utilises uniform departures, random arrivals and does
C     not account for delay due to acceleration or deceleration.
C
C     Alphabetical list of memory variables (all variables in seconds
C     unless otherwise noted)
C
C c   ANS1       = variable used to store result of re-run question at
C                  end of program
C r   AVGDELAY   = calculated average delay
```

```
C r   AVGPEDHDWY= calculated average ped headway
C r   AVGVHDWY  = average vehicle headway
C
C l   BPUSH     = logical variable for Button Pushed y/n
C
C i   CHKTM     = time check to determine if in red or green phase
C i   CLOCK     = time clock
C c   COORD     = is the x-walk coordinated with the signals
C c   COORDF    = input variable for x-walk coordination
C r   CYCLE     = variable used to store real value of the current cycle
C i   CYCLETM1  = user input cycle time for intersection #1
C i   CYCLETM2  = user input cycle time for intersection #2
C
C i   DELAY     = delay time incurred by vehicle
C i   DELAYSUM  = sum of all vehicle delays at current intersection
C i   DSCHTM    = time that vehicle is discharged
C
C i   ENDTIME   = time at which the TSD must stop plotting
C
C i   IHDWY     = rounded integer value of the calculated headway
C i   INTRED    = array to store time of intersection RED interval
c i   IR        = counter for intersection red intervals
C
C i   MAX       = maximum number of vehicles to plot for TSD
C i   MAXVHRED  = maximum vehicle red time at pedestrian x-ing
C               = PEDGREEN + PEDCLR
C i   MINVHGR   = minimum vehicle phase green time
C
C i   NCYCLE    = truncated value of cycle
C i   NRED      = counter for which red interval the signal is at
C i   NTHRU     = number of through vehicles
C
C i   OFFSET1   = offset between signal one and signal two
C i   OFFSET2   = offset between signal two and signal three
C i   ONPRVDIS  = previous discharge time of side street vehicle
C r   ONTRNHDWY = on-turning traffic headway (seconds)
C r   ONTRNVLM  = on-turning traffic volume (vph)
C
C i   PEDARVL   = pedestrian arrival time
C i   PEDCLR    = pedestrian clearance time for X-walk
C i   PEDCNT    = pedestrian counter used in a loop
C i   PEDDATA   = array to store pedestrian arrival time max. 1000 peds
C i   PEDGREEN  = length of pedestrian green phase
C i   PEDHDWY   = pedestrian arrival headway
C i   PEDTIMER  = timer to determine length of ped walk phase
C i   PEDVOL    = pedestrian volume, input by user
C r   PHDWY     = calculated pedestrian headway (real)
C i   PREVDIS   = previous time of discharge
C c   PRNDETL   = if set to YES then print out a detailed report
C               = if set to NO then print only a summary
```

```
C
C l   RED        = logical variable to see if vehicle signal is red
C i   RI         = red index
C r   RNDM       = random number storage variable
C r   RNDMFNC    = random number generator function
C
C r   SATFL      = user input saturation flow rate
C r   SCALE      = scaling factor used to obtain realistic headways
C i   SEED       = seed number for random number generator
C i   SFHDWY     = saturation flow headway
C i   SIMTIME    = duration of simulation in seconds
C i   STARTTIME = time at which the TSD must start plotting
C r   SUMPEDHDWY= sum of calculated ped headways
C r   SUMPEDDLY = sum of the pedestrian delays
C i   SUMVHDWY   = sum of calculated vehicle headways
C
C i   THISGR     = vehicle green phase at ped x-ing (calculated)
C r   THRUHDWY   = through movement traffic headway (seconds)
C r   THRUVLM    = through movement traffic volume (vph)
C i   TIME       = point within the cycle, varies between 1 to CYCLETM
C i   TMVHARV    = time that vehicle arrives in the system (seconds)
C i   TRAVEL1    = travel time between signal one and signal two
C i   TRAVEL2    = travel time between signal two and signal three
C c   TSD        = input variable (Y/N) to print out a TSD
C i   TSDEND     = last vehicle number to plot on the TSD
C i   TSDSTART   = first vehicle number to plot on the TSD
C i   TSIMH      = input simulation time in hours
C
C i   VEHDELAY   = vehicle delay (seconds)
C i   VEHRED     = array to store clock time for begin vehicle red phase
C i   VEHTIMER   = timer to determine length of vehicle green phase
C l   VHGREEN    = logical variable to determine begin of vehicle green
C r   VHGRTM1    = phase vehicle green interval Int #1 (seconds)
C r   VHGRTM2    = phase vehicle green interval Int #2 (seconds)
C i   VEHHDWY    = calculated vehicle headway (seconds)
C i   VEHICLE    = a 5000 x 8 array used to store information regarding
C                  each vehicle
C                  1 - arrival time at Int #1
C                  2 - departure time from Int #1
C                  3 - arrival time at ped crossing
C                  4 - departime time from ped crossing
C                  5 - arrival time at Int #2
C                  6 - departure time from Int #2
C                  7 - running total of delay to vehicle
C                  8 - either T for Through Vehicle or
C                              S for Side Street Vehicle
C
C r   VHREDTM1   = phase vehicle red interval Int #1 (seconds)
C r   VHREDTM2   = phase vehicle red interval Int #2 (seconds)
C i   VHCNTR     = vehicle counter
```

```
C
C l   WALK       = logical variable if ped phase still on walk
C
C
C     Type Declaration of ALL variables
C
      CHARACTER*1 ANS1,PRNDETL,COORDF,COORD,TSD

      INTEGER CHKTM,CLOCK,CYCLETM1,DELAY,DELAYSUM,DSCHTM
      INTEGER IHDWY,MINVHGR,NCYCLE,OFFSET1,OFFSET2
      INTEGER PEDARVL,PEDCLR,PEDCNT,PEDDATA(2000,2),PEDGREEN,PEDHDWY
      INTEGER PEDTIMER,PEDVOL,PREVDIS,RI,SEED,SIMTIME,THISGR
      INTEGER TIME,TMVHARV,TRAVEL1,TRAVEL2,TSIMH,VEHDELAY
      INTEGER VEHRED(500),VEHICLE(5000,8),VEHTIMER,VHCNTR
      INTEGER SFHDWY,MAXVHRED,TOTLDELAY,TSDEND,TSDSTART
      INTEGER ENDTIME,STARTTIME,INTRED(500),CYCLETM2

      LOGICAL BPUSH,FLAG,RED,VHGREEN,WALK,FIRST,COORD
      LOGICAL FLAG1,FLAG2,FLAG3,FLAG4,FLAG5,FLAG6

      REAL AVGDELAY,AVGPEDHDWY,AVGVHDWY,CYCLE,ONTRNHDWY,RNDM
      REAL RNDMFNC,SATFL,SCALE,RSFHDWY,VHGRTM,VHREDTM,THRUHDWY
      REAL PHDWY,THRUVLM,ONTRNVLM,SUMVHDWY,VEHHDWY,SUMPEDHDWY
      REAL AVGTOTDELAY,VHGRTM2,VHREDTM2
C
C     Initialise the scale factor
C
      SCALE = 0.90
C
C     Set the FLAG equal to TRUE for the first iteration ONLY
C
      FLAG = .TRUE.
C
C     Open up the file named "INPUT.DAT" from which to read in the
C     input data
C
1001  OPEN (7,FILE='INPUT.DAT',STATUS='OLD')
C
C     Open up a file, OUTPUT.DAT, to which to write the output data
C
      OPEN (6,FILE='OUT',STATUS='UNKNOWN')
C
C     Read in the data values to be used in the evaluation
C
      READ(7,1002) THRUVLM,ONTRNVLM,SATFL,TSIMH,SEED,VHREDTM1,VHGRTM1,
     +       VHREDTM2,VHGRTM2,PEDVOL,PEDGREEN,PEDCLR,TRAVEL1,TRAVEL2,
     +       OFFSET2,CYCLETM1,CYCLETM2,MINVHGR,TSDEND,TSDSTART,
     +       PRNDETL,COORDF,TSD
1002  FORMAT(3F5.0,2I5,4F5.0,11I5,3A1)
C
```

```
C
C     Check values of input data
C
C     Initialise the CO-ORDINATION flag to FALSE, i.e. the pedxing is
      not coordinated with the other two intersections

      COORD = .FALSE.
C
C     If the user requests coordination then set the CO-ORDINATION flag
C     to TRUE
C
      IF (COORDF.EQ.'Y'.OR.COORDF.EQ.'y') COORD = .TRUE.
C
C     Set the index counter for the intersection red interval start time
C     to 1.
C
      IR = 1
C
C     Set the first intersection red interval start time = 0.  Due to
C     the manner in which the program was designed, the first
C     intersection will always commence operations on a red signal.
C
      INTRED(IR) = 0
C
C     Check what the overall network V/C ratio is.  If the V/C ration
C     exceeds 0.80 then display an error message and STOP the program
C     operation.
C
      IF (((THRUVLM+ONTRNVLM)/(SATFL*VHGRTM/CYCLETM1)).GT.0.80) THEN
         WRITE(*,7601)
7601     FORMAT(2X,'ERROR: V/C ratio exceeds 0.80, program halted')
         GOTO 9999
      ENDIF
C
C     Check if the vehicle red interval plus the vehicle green interval
C     exceeds the cycle time.  If it does, display an error message and
C     halt the program operation. FIRST intersection
C
      IF ((VHREDTM1+VHGRTM1).GT.CYCLETM1) THEN
         WRITE (*,7602)
7602     FORMAT(2X,'ERROR: Red Interval + Green Interval exceeds Cycle
     +          Time',  /,10X,'PROGRAM HALTED.',//)
         GOTO 9999
      ENDIF
C
C     Check if the vehicle red interval plus the vehicle green interval
C     exceeds the cycle time.  If it does, display an error message and
C     halt the program operation. SECOND intersection
C
      IF ((VHREDTM2+VHGRTM2).GT.CYCLETM2) THEN
```

```
         WRITE (*,7602)
         GOTO 9999
      ENDIF
C
C     Check the length of the vehicle green interval, if it is less than
C     7.0 seconds, display an errorr message and halt the program
C     operation.
C
      IF(VHGRTM.LT.7.0) THEN
         WRITE (*,7603)
7603     FORMAT(2X,'ERROR: Vehicle Green time must be greater than 7 s',
     +         /,10X,'program halted.',//)
         GOTO 9999
      ENDIF
C
C     Check the length of the pedestrian green interval, if it is less
C     than 7.0 seconds, display an error message and halt the program
C     operation.
C
      IF(PEDGREEN.LT.7.0) THEN
         WRITE (*,7604)
7604     FORMAT(2X,'ERROR: Pedestrian Green must be greater than 7 s',
     +         /,10X,'program halted.',//)
         GOTO 9999
      ENDIF
C
C     Check the length of the vehicle green interval at the crosswalk if
C     it is less than 7.0 seconds, display an warning message asking the
C     user if he wishes to continue or to halt the program operation.
C
      IF(MINVHGR.LT.7.0) THEN
         WRITE (*,7605)
7605     FORMAT(2X,'WARNING: The minimum vehicle green interval at the',
     +         ' crosswalk is less than 7 seconds.',/,
     +         2X, 'Do you wish to continue (Y/N) ? :',/)
         READ(*,7606)ANS1
7606     FORMAT(A1)
         IF (ANS1.EQ.'N'.OR.ANS1.EQ.'n') GOTO 9999
      ENDIF
C
C     If the user put a lower case "Y" into the input file then convert
C     it to upper case
C
      IF (PRNDETL.EQ.'y') PRNDETL = 'Y'
C
C     If the user requests a detailed output then open up a unit for the
C     printer to print out the TSD plot.  Note: the plot CANNOT be
C     redirected to a file for printing later due to the nature of the
C     print commands used.
C
```

```
      IF (PRNDETL.EQ.'Y') THEN
         WRITE(*,7690)
         FORMAT(2X,'PLEASE ensure that the printer is on and is set up
     +             for compressed printing (80 column printer) or
     +             standard printing with wide (132 column) paper",//)
         PAUSE
         OPEN(8,FILE='PRN')
      ENDIF
C
C     Write all of the user specified data to the output file
C
      WRITE(6,1009) THRUVLM,ONTRNVLM,SATFL,TSIMH,SEED,VHREDTM1,VHGRTM1,
     +       VHREDTM2,VHGRTM2,PEDVOL,PEDGREEN,PEDCLR,TRAVEL1,TRAVEL2,
     +       OFFSET2,CYCLETM1,CYCLETM2,MINVHGR,COORDF,TSD,PRNDETL
1009  FORMAT(//,10X,'PEDESTRIAN CROSSING EVALUATION',///,
     +5X,'Through traffic volume (pcu/h)             :  ',F5.0,/,
     +5X,'Side street on turn traffic volume         :  ',F5.0,/,
     +5X,'Stopline saturation flow (pcu/h*gr)        :  ',F5.0,/,
     +5X,'Duration of simulation (minutes)           : ',I5,/,
     +5X,'Seed Number (odd three digit)              : ',I5,/,
     +5X,'Vehicle Red Interval #1 (seconds)          :  ',F5.0,/,
     +5X,'Vehicle Green Interval #1 (seconds)        :  ',F5.0,/,
     +5X,'Vehicle Red Interval #2 (seconds)          :  ',F5.0,/,
     +5X,'Vehicle Green Interval #2 (seconds)        :  ',F5.0,/,
     +5X,'Pedestrian volume (peds/h)                 : ',I5,/,
     +5X,'Pedestrian green time (seconds)            : ',I5,/,
     +5X,'Pedestrian clearance time (seconds)        : ',I5,/,
     +5X,'Travel time (Int.1 to ped crossing, seconds) : ',I5,/,
     +5X,'Travel time (Ped crossing to Int.2, seconds) : ',I5,/,
     +5X,'Signal Offset (seconds)                    : ',I5,/,
     +5X,'Intersection #1 cycle time (seconds)       : ',I5,/,
     +5X,'Intersection #2 cycle time (seconds)       : ',I5,/,
     +5X,'Minimum vehicle green time at ped X-ing (sec): ',I5,/,
     +5X,'PEDXING coordinated with signals (Y/N)     :     ',A1,/,
     +5X,'Print the Time Space Diagram (Y/N)         :     ',A1,/,
     +5X,'Produce detailed report                    :     ',A1,///)
C
C
C     *****************************************************************
C
C     Intersection #1 calculations
C
C     *****************************************************************
C
C     If the FLAG is set TRUE and the V/C ratio is greater than 0.70
C     then start with a lower value of scale.  The flag is set TRUE fo
C     the first iteration of the program only, otherwise SCALE would
C     allways be set to 0.70
C
```

```
      IF (FLAG.AND.(THRUVLM/(SATFL*VHGRTM/CYCLETM)).GT.0.70) THEN
         SCALE = 0.70
      ENDIF
C
C     Initialise all of the variables to be used in this module of the
C     program.
C
      PREVDIS = 0
      SUMVHDWY = 0
      AVGVHDWY = 0
      SUM = 0
      TMVHARV = 0
      N = 0
      NTHRU = 0
      CLOCK = 0
C
C     Calculate the through traffic average headway
C
      THRUHDWY = 3600/THRUVLM
C
C     Calculate the on-turn traffic headway.  This value assumes that
      vehicles will arrive only during the mainstreet red phase and
      assumes a uniform (non-random) arrival rate and pattern
C
      ONTRNHDWY = NINT(((3600/CYCLETM1)*VHREDTM1)/ONTRNVLM)
C
C     Set the time of discharge for the previous sidestreet vehicle to a
C     value equal to the negative of the average headway.  This is done
C     so that for the first interval a vehicle will discharge as soon as
C     the signal is green for the sidestreet traffic
C
      ONPRVDIS = -ONTRNHDWY
C
C     Calculate the real value of the saturation flow headway
C
      RSFHDWY = 3600/SATFL
C
C     Calculate the integer value of the saturation flow headway
C
      SFHDWY = NINT(RSFHDWY)
C
C     Convert the input simulation time from minutes to seconds
C
      SIMTIME = TSIMN * 60
C
C     Initialize the random number generator by calling the function and
C     passing the seed number to it.
C
      RNDM = RNDMFNC(SEED)
C
```

```
C     Increment the vehicle counter
C
1004  N = N + 1
C
C     Check to see if the program has looped so far that the scale = 1.0
C
      IF (SCALE.GE.1.0) SCALE = 0.99
C
C     Random number is factored by SCALE
C
      RNDM = RNDMFNC(0)*SCALE
C
C     Using the random number calculate the next vehicle headway using a
C     shifted negative exponential function.  The function is shifted by
C     2.0 in order to maintain a minimum vehicle headway of 2.0 seconds
C
      VEHHDWY = 2 - (THRUHDWY*LOG(1-RNDM))
C
C     Roundoff the value of the headway to an integer value
C
      IHDWY = NINT(VEHHDWY)
C
C     Calculate the sum of the real value headways to be used as a check
C     at the end of the module
C
      SUMVHDWY = SUMVHDWY + VEHHDWY
C
C     Calculate the arrival time of the next vehicle
C
      TMVHARV = TMVHARV + IHDWY
C
C     Increment the time clock
C
1005  CLOCK = CLOCK + 1
C
C     If the vehicle arrival time is greater than the clock time then
C     jump to the end of the module otherwise keep processing
C     Conditional IF #1
C
      IF (TMVHARV.LE.SIMTIME) THEN
C
C     Check if the clock is less than or equal to the  duration of the
C     simulation, if it is then continue processing.
C     This is conditional IF #2
C
         IF (CLOCK.LE.SIMTIME) THEN
C
C     Determine what cycle number the signal is at by dividing the clock
C     time by the cycle time.
C
```

```
          CYCLE = CLOCK/CYCLETM1
C
C    Convert the cycle number to an integer by truncating the value of
C    cycle.  For example INT(3.7) = 3
C
          NCYCLE = INT(CYCLE)
C
C    Calculate how far into the green phase the signal is at
C
          TIME = CLOCK - (NCYCLE * CYCLETM1)
C
C    Now calculate a check variable to determine whether or not the
C    phase has changed to red
C
          CHKTM = TIME - VHREDTM1
C
C    This is the check to see if the signal is red or green.  If it is
C    green then CHKTM will be greater than or equal to zero and the
C    program will continue to process.  If the signal is red then the
C    program will begin discharging the sidestreet traffic
C    This is conditional IF #3.
C
          IF (CHKTM.GE.0) THEN
C
C    If the clock is greater than or equal to the Vehicle Arrival Time
C    then keep processing otherwise loop back to increment the time
C    clock
C    Conditional IF #4
C
             IF (CLOCK.GEVHARV) THEN
C
C    This DO loop is the main processing portion of the module.  The
C    counter, J, can go from 1 to Vehicle Green Time.
C
                DO 1006 J = 1, VHGRTM1
C
C    Set the variable DSCHTM equal to J
C
                   DSCHTM = J
C
C    If the CHKTM + DSCHTM is greater than the Vehicle Green Time then
C    loop back to line labeled 1005.  In other words the vehicle would
C    be crossing the stopline during RED if the condition evaluates to
C    TRUE.  If it does evaluate to TRUE then loop back to increment the
C    clock to get to the next green interval.
C
                   IF ((CHKTM+DSCHTM).GT.VHGRTM1) GOTO 1005
C
C    If the CLOCK time plus the DISCHARGE time minus the time at which
C    the previous vehicle discharged is greater than the Saturation
```

```
C     Flow headway then continue processing, otherwise jump down to
C     increment the DO loop.  This is conditional IF #5
C
                IF ((CLOCK+DSCHTM - PREVDIS).GE.SFHDWY) THEN
C
C     Check if the CLOCK minus the time at which the previous vehicle
C     discharged is greater than the Saturation Flow headway.  If the
C     condition evaluates to TRUE then the vehicle does not slow down or
C     stop at the intersection.
C
                  IF ((CLOCK - PREVDIS).GE.SFHDWY) DSCHTM = 0
C
C     Calculate the vehicle delay by adding the CLOCK time plus the
C     Discharge Time and subtracting the Vehicle Arrival time.
C
                    DELAY = (CLOCK + DSCHTM) - TMVHARV
C
C     Check to see if somehow the calculated delay evaluates to less
C     than zero then set the delay equal to 0.
C
                    IF (DELAY.LT.0) DELAY = 0
C
C     Store the vehicle discharge time in the variable PREVDIS to be
C     used in the next iteration of the loop.
C
                    PREVDIS = CLOCK + DSCHTM
C
C     Store the vehicle arrival time in the array
C
                    VEHICLE(N,1) = TMVHARV
C
C     Store the vehicle discharge time in the array
C
                    VEHICLE(N,2) = CLOCK + DSCHTM
C
C     Store the vehicle delay in the array
C
                    VEHICLE(N,7) = DELAY
C
C     Store a variable in the array to indicate on the TSD if the
C     vehicle is a through or on-turn vehicle.
C
                    VEHICLE(N,8) = 'T'
C
C     Sum up the delay to each vehicle so that an average delay can be
C     calculated for the intersection.
C
                    DELAYSUM = DELAYSUM + DELAY
C
```

```
C     To correctly calculate the intersection delay and headways for the
C     mainstreet traffic, a separate vehicle counter must be established
C
                  NTHRU = NTHRU + 1
C
C     Loop back to line label 1004 so that the vehicle counter can be
C     incremented.
                  GOTO 1004
C
C     This is the ENDIF statement for Conditional IF #5
C
               ENDIF
C
C     This is the CONTINUE statement for the end of the DO loop.
C
1006        CONTINUE
C
C     Endif statement for Conditional IF #4
C
         ENDIF
C
C     If the mainstreet signal is RED then discharge the sidestreet
C     traffic
C     Else for Conditional IF #3
C
      ELSE
C
C     If the clock minus the discharge time of the previous sidestreet
C     vehicle is greater than or equal to the sidestreet traffic headway
C     then discharge another vehicle from the sidestreet
C     Conditional IF #6
C
         IF (CLOCK-ONPRVDIS.GE.ONTRNHDWY) THEN
C
C     Store the arrival and discharge time into the Vehicle data array
C     Store the vehicle type in the array i.e. Side Street Vehicle
C
            VEHICLE(N,1) = CLOCK
            VEHICLE(N,2) = CLOCK
            VEHICLE(N,8) = 'S'
C
C     Store the discharge time in the previous discharge time variable
C
            ONPRVDIS = CLOCK
C
C     Increment the overall vehicle counter
C
            N = N + 1
C
```

```
C     Endif statement for Conditional IF #6
C
               ENDIF
C
C     If the variable CHKTM is equal to the negative of the red interval
C     time then the signal must be red for the through vehicles.  This
C     condition will occur only once per cycle.
C     Conditional IF #7
C
               IF(CHKTM.EQ.-VHREDTM) THEN
C
C     Increment the index for the INTRED array
C
                  IR = IR + 1
C
C     Store the clock time into the INTRED array.  This is the time at
C     which the signal changed from GREEN to RED.  This value is
C     required for later modules of the program.
C
                  INTRED(IR) = CLOCK
C
C     Endif statement for Conditional IF #7
C
               ENDIF
C
C     Endif statement for Conditional IF #3
C
            ENDIF
C
C     Loop back to increment the clock without incrementing the vehicle
C     counter.  This statement is reached only if the signal phase is
C     red when a vehicle wishes to discharge.
C
            GOTO 1005
C
C     This is the ENDIF statement for Conditional IF #2
C
         ENDIF
C
C     This is the ENDIF statement for Conditional IF #1
C
      ENDIF
C
C     This point is reached only when the CLOCK reaches the Simulation
C     Time.  Calculate the average delay by taking the total delay and
C     dividing by the number of discharged vehicles.  The denominator is
C     N - 1 because the vehicle counter increments before the clock is
C     checked to see if it exceeds the Simulation Time.
C
```

```
1111  AVGDELAY = DELAYSUM/(NTHRU - 1)
C
C     Calcualte the average headway by dividing the total of all
C     headways by the number of vehicles.
C
      AVGVHDWY = SUMVHDWY/(NTHRU - 1)
C
C     Check to see if the scale factor was sufficient to generate the
C     correct number of vehicles as specified by the user.  Do this by
C     comparing the average headway to the through volume headway.  If
C     different is too large then the SCALE factor must be adjusted and
C     entire module rerun.  Conditional IF #4
C
      IF ((AVGVHDWY+0.02).LE.THRUHDWY) THEN
C
C     Increment the scale factor by 0.01
C
         SCALE = SCALE + 0.01
C
C     Close the input data file
C
         CLOSE(7)
C
C     Close and delete the output data file - the results are not valid
C
         CLOSE(6,STATUS='DELETE')
C
C     Set the flag to FALSE so that the SCALE factor is not reset to
C     0.70 at the beginning of this module
C
         FLAG = .FALSE.
C
C     Loop back to line labeled 1001 to restart this module.
C
         GOTO 1001
C
C     This is the ENDIF statement for Conditional IF #4
C
      ENDIF
C
C     If the user requested a detailed output from the program then
C     print out the vehicle number, time of arrival, the delay and the
C     time of discharge. (Mainstreet volume only)
C
      IF (PRNDETL.EQ.'Y') THEN
         DO 1112 JJ = 1, N - 1
            IF (VEHICLE(JJ,8).EQ.'T') THEN
               WRITE(6,7771)JJ,VEHICLE(JJ,1),VEHICLE(JJ,2),
     +                      DELAY,VEHICLE(JJ,7)
```

```
            ENDIF
1112     CONTINUE
C
C     If the user specified a detailed output then print to the file the
C     vehicle number and the discharge time (SIDESTREET traffic)
C
         DO 1113 JJ = 1, N - 1
            IF (VEHICLE(JJ,8).EQ.'S') THEN
               WRITE (6,7776)JJ,VEHICLE(JJ,1)
            ENDIF
1113     CONTINUE
      ENDIF
C
C     Write to the file the average vehicle delay and the total average
C     delay.  For the first intersection the average delay and the total
C     average delay are identical.
C
      WRITE(6,7772)AVGDELAY,AVGDELAY
C
C     Set a variable, VHCNTR equal to the number of vehicles.  The
C     counter will be used in later modules to prevent the program from
C     trying to evaluate too many vehicles.
C
      VHCNTR = N - 1
C
C     *******************************************************************
C
C     Pedestrian Arrivals Calculations
C
C     This section calculates the arrival times of all of the pedestrians
C     using the random sub-function listed at the end of this program.
C     The program will continue to iterate until there are less pedestrian
C     arrivals per hour than are specified by the user.
C
C     *******************************************************************
C
C     If the user has specified pedestrians crossing the roadway then
C     utilise this module otherwise skip over it.  Conditional IF #8
C
      IF (PEDVOL.GT.1.) THEN
C
C     Initialise the Pedestrian headway to 0
C
         PEDHDWY = 0
C
C     For the first run approximate the scale factor using a
C     theorectically derived formula
C
         SCALE = -0.00011*PEDVOL+1.11
```

```
C
C     Increment the scale factor by [illegible]1.  The program module loops up
C     to this point, incrementing the scale factor each time until the
C     module yields suitable results for pedestrian generation.
C
2000     SCALE = SCALE + 0.01
C
C     Set the pedestrian counter equal to 1
C
         PEDCNT = 1
C
C     Set the pedestrian arrival time equal to 0
C
         PEDARVL = 0
C
C     This DO loop generates the pedestrian arrival headways.  The loop
C     continues from Pedestrian Counter from 1 to total pedestrian
C     volume.
C
         DO 2001 PEDCNT = 1,PEDVOL
C
C     Generate a random number by calling the random number generator
C
            RNDM = RNDMFNC(0)
C
C     Generate a real number value for the pedestrian headway.  The
C     headways are generated using a Negative Exponential function.
C     Unlike the vehicle headways, pedestrian headways may be 0, i.e.
C     pedestrians arrive simultaneously.
C
            PHDWY = SCALE*ABS((3600/PEDVOL)*(LOG(1-RNDM)))
C
C     Round off the ped headway to an integer value
C
            PEDHDWY = NINT(PHDWY)
C
C     Sum up all of the pedestrian headways to be used at the end of the
C     as a check
C
            SUMPEDHDWY = SUMPEDHDWY + PHDWY
C
C     The pedestrian arrival time is equal to the previous pedestrian
C     arrival time plus the just calculated pedestrian headway
C
            PEDARVL = PEDARVL + PEDHDWY
C
C     Store the pedestrian arrival time into the pedestrian data array
C
            PEDDATA(PEDCNT,1) = PEDARVL
```

```
C
C     Now for some conditional checks of the data.
C
C     If the pedestrian arrival time is greater than the simulation time
C     AND if the pedestrian counter is greater than the pedestrian
C     volume then break out of the DO loop and go to line 2222
C
          IF (PEDARVL.GE.SIMTIME.AND.PEDCNT.LE.PEDVOL) GOTO 2222
C
C     If the pedestrian arrival time is greater than the simulation time
C     then loop back up to line 2000.  The scale factor will be
C     increased and all of the pedestrian arrival times regenerated.
C
          IF (PEDARVL.GT.SIMTIME) GOTO 2000
C
C     If the pedestrian counter is greater than the pedestrian volume
C     then loop back up to line 2000.  The scale factor will be
C     increased and all of the pedestrian arrival times regenerated.
C
          IF (PEDCNT.GT.PEDVOL) GOTO 2000
C
C     End of the DO loop
C
2001     CONTINUE
C
C     Calculate the average pedestrian headway based on the randomly
C     generated individual pedestrian headways.
C
2222     AVGPEDHDWY = SUMPEDHDWY/(PEDCNT - 1)
C
C     Check if the average pedestrian headway is within 0.02 of the
C     overall average pedestrian headway.  If it is not then loop back
C     to the beginning of the module to regenerate all of the pedestrian
C     arrival times.
C
         IF ((AVGPEDHDWY + 0.02).LE.(3600/PEDVOL))  GOTO 2000
C
C     Continue running through the module
C
         CONTINUE
C
C     This is the ENDIF for conditional IF #8
C
      ENDIF
C
C
C     ********************************************************************
C
C     Pedestrian Signal Operations
```

```
C
C     *******************************************************************
C
C
C     If the user has specified a pedestrian volume then use this module
C     Conditional IF #9
C
      IF (PEDVOL.GT.1) THEN
C
C     Initialise a number of variables
C
         CLOCK = 0
         VENTIMER = 0
         IR = 1
         RI = 1
         PEDCNT = 0
         PEDARVL = 0
         WALK = .FALSE.
         BPUSH = .FALSE.
         VHGREEN = .TRUE.
         FIRST = .TRUE.
         PEDTIMER = 0
C
C     Increment the pedestrian counter
C
3000     PEDCNT = PEDCNT + 1
C
C     The pedestrian arrival time is obtained from the pedestrian data
C     array
C
         PEDARVL = PEDDATA(PEDCNT,1)
C
C     If the WALK phase is TRUE and the pedestrian arrival time is less
C     than the CLOCK time then the pedestrian is allowed to cross
C     Conditional IF #10
C
3002     IF (WALK.AND.PEDARVL.LE.CLOCK) THEN
C
C     The pedestrian delay is equal to the clock time minus the arrival
C     time and is stored in the pedestrian data array
C
            PEDDATA(PEDCNT,2) = CLOCK - PEDARVL
C
C     If the user requests a detailed output from the program then print
C     out the Pedestrian Count, Pedestrian Arrival Time, Clock Time and
C     the Pedestrian Delay.
C
            IF (PRNDETL.EQ.'Y') THEN
               WRITE(6,7773)PEDCNT,PEDDATA(PEDCNT,1),CLOCK,
     +                      PEDDATA(PEDCNT,2)
C
C     Sum up the pedestrian delay to later calculate an average delay
C     per pedestrian
C
            SUMPEDDLY = SUMPEDDLY + PEDDATA(PEDCNT,2)
            ENDIF
C
C     Loop back to line 3000 to obtain the next pedestrian
C
            GOTO 3000
C
C     If the pedestrian arrival time is greater than the clock time or
C     if the WALK phase was not activated
C
         ELSE
C
C     If the WALK phase is not activated and the Vehicle Green phase is
C     activated then proceed into the DO loop
C     Conditional IF #11
C
            IF (.NOT.WALK.AND.VHGREEN) THEN
C
C     Set up a clock timer that increments from 1 to the Simulation Time
C
               DO 3001 CLKTM = 1,SIMTIME
C
C     Increment the time CLOCK
C
                  CLOCK = CLOCK + 1
C
C     Increment the vehicle green phase timer
C
                  VEHTIMER = VEHTIMER + 1
C
C     If the pedestrian counter is greater than the pedestrian volume or
C     if the clock is greater than the simulation time then break out of
C     this module to continue on with the next module
C
                  IF(PEDCNT.GT.PEDVOL.OR.CLOCK.GE.SIMTIME) GOTO 3333
C
C     If the pedestrian arrival time is less than the clock time then
C     set the Button Push to TRUE
C
                  IF (PEDDATA(PEDCNT,1).LE.CLOCK) BPUSH = .TRUE.
C
C     If the PEDXING signal is coordinated with the intersection signals
C     then execute the commands following
C     Conditional IF #12
```

```
C
                  IF (COORD) THEN
C
C     Set the Red clock time equal to the upstream intersection clock
      red time plus the travel time from Int. #1 to the Ped Xing
C
                    NRED = INTRED(IR) + TRAVEL1
C
C     If the clock has been incremented past the next allowable pedxing
C     red clock time then increment the red time.  This condition is
C     true only if no pedestrian has pushed the button for an activation
C     for the next coordinated pedxing red interval
C
                    IF (CLOCK.GT.NRED) IR = IR + 1
C
C     If the clock is equal to the time of the beginning of the red
C     interval from Intersection #1 plus the travel time (for
C     coordination) AND a pedestrian has activated the signal.
C     Conditional IF #13
C
                    IF (CLOCK.EQ.(INTRED(IR)+TRAVEL1).ANDUSH) THEN
C
C     Set the WALK indication to TRUE
C
                      WALK = .TRUE.
C
C     The time that the vehicle red interval begins at the PEDXING is
C     equal to the CLOCK time.
C
                      VEHRED(RI) = CLOCK
C
C     Increment the index for the vehicle red interval array
C
                      RI = RI + 1
C
C     Set the button push and first iteration flags to FALSE
C
                      BPUSH = .FALSE.
                      FIRST = .FALSE.
C
C     Loop up to line 3002 to discharge the pedestrian
C
                      GOTO 3002
C
C     Endif for Conditional IF #13
C
                    ENDIF
C
C     If the PEDXING signal is not coordinated with the intersection
```

```
      signals then execute the commands following.
C     Else for Conditional IF #12
C
                 ELSE
C
C     If the vehicle green phase timer is greater than the minimum
C     vehicle green AND a pedestrian has arrived and pushed the button
C     to call the pedestrian walk phase OR if this is the first run
C     through this portion of the module and the button has been pushed.
C     This module assumes that the vehicle green phase remains activated
C     until a pedestrian call to the signal
C     Conditional IF #14
C
                    IF ((VEHTIMER.GE.MINVHGR.ANDUSH).OR.
     +                 (FIRST.ANDUSH))THEN
C
C     Set the WALK indicator to TRUE
C
                       WALK = .TRUE.
C
C     Reset the vehicle green timer to 0
C
                       VEHTIMER = 0
C
C     Store the time at which the vehicle phase changes to red in the
C     VEHICLE RED data array for use in the next module
C
                       VEHRED(RI) = CLOCK
C
C     Increment the counter for the red intervals
C
                       RI = RI + 1
C
C     Set the button push and first iteration flags to FALSE
C
                       BPUSH = .FALSE.
                       FIRST = .FALSE.
C
C     Loop up to line 3002 to discharge the pedestrian
C
                       GOTO 3002
C
C     Endif for Conditional IF #14
C
                    ENDIF
C
C     Endif for Conditional IF #12
C
                 ENDIF
```

```
C
C     Continue statement to end the DO loop
C
3001           CONTINUE
C
C     Endif for Conditional IF #11
C
            ENDIF
C
C     Endif for Conditional IF #10
C
         ENDIF
C
C     If the pedestrian walk phase timer is greater than the specified
C     pedestrian green time then set the WALK signal to FALSE and keep
C     the Vehicle Green Phase at FALSE to allow for the pedestrian
C     clearance time.
C
         IF (PEDTIMER.GE.PEDGREEN) THEN
            WALK = .FALSE.
            VHGREEN = .FALSE.
         ENDIF
C
C     If the pedestrian timer is greater than the pedestrian green time
C     plus the pedestrian clearance time  then set the WALK phase to
C     FALSE, the vehicle green phase to TRUE, reset the pedestrian timer
C     to 0, and substract 1 second from the clock to keep the clock set
C     correctly.
C
         IF(PEDTIMER.GE.(PEDGREEN + PEDCLR)) THEN
            WALK = .FALSE.
            VHGREEN = .TRUE.
            PEDTIMER = 0
            CLOCK = CLOCK - 1
         ENDIF
C
C     Increment the clock
C
         CLOCK = CLOCK + 1
C
C     If the pedestrian counter exceeds the pedestrian volume or if the
C     clock is greater than or equal to the simulation time then jump to
C     the end of this module, line 3333
C
         IF(PEDCNT.GT.PEDVOL.OR.CLOCK.GE.SIMTIME) GOTO 3333
C
C     If the WALK signal is on OR if the walk signal is not on and the
C     vehicle green is not on (i.e. pedestrian clearance time) then
C     increment the pedestrian phase timer
```

```
C
         IF (WALK.OR.(.NOT.WALK.AND..NOT.VHGREEN))PEDTIMER=PEDTIMER+1
C
C     Jump to line 3002 to discharge the pedestrian
C
         GOTO 3002
C
C     Continue statement to maintain program flow
C
3333     CONTINUE
C
C     One last increment for the vehicle red counter
C
         RI = RI + 1
C
C     Endif for Conditional IF #9
C
      ENDIF
C
C     If the detailed print out is requested print out the times at
C     which the pedxing was red for the vehicles
C
      IF (PRNDETL.EQ.'Y') THEN
         DO 3335 JJ = 1, RI
            WRITE(6,7774)VEHRED(JJ),JJ
3335     CONTINUE
      ENDIF
C
C     Calculate and print out the average pedestrian delay
C
      AVGPEDDLY = SUMPEDDLY/PEDCNT
      WRITE(6,7775)AVGPEDDLY
C
C     Set the last vehicle red interval to begin at the end of the
C     simulation.  This is required for the next module to function
C     properly to calculate green times.  If there are no pedestrians
C     then the only vehicle red time will be at the simulation time.
C
      VEHRED(RI) = SIMTIME
C
C
C     ******************************************************************
C
C     Intersection #2 Delay Calculations
C
C     Now perform the delay calculations for the pedestrian crossing by
C     taking the results from the first intersection (stored in the VEH
C     array) and the results from the pedestrian crossing and utilizing
C     them in the second intersection
```

```
C
C     ******************************************************************
C
C     Initialize variables

      PREVDIS = 0
      DELAYSUM = 0
      AVGDELAY = 0
      TMVHARV = 0
      RI = 1
      N = 0
      CLOCK = 0
      RED = .FALSE.
C
C     The maximum length of the vehicle red time is the sum of the
C     pedestrian green time plus the pedestrian clearance time
C
      MAXVHRED = PEDGREEN + PEDCLR
C
C     Increment the vehicle counter
C
4001  N = N + 1
C
C     If the counter is greater than the number of vehicles generated in
C     module #1 then skip over the calculations
C     Conditional IF #15
C
      IF (N.LE.VHCNTR) THEN
C
C     Obtain the vehicle arrival time by taking the departure time from
C     intersection #1 and adding the travel time from intersection #1 to
C     intersection #2
C
         TMVHARV = VEHICLE(N,2) + TRAVEL1
C
C     Increment the time clock
C
4002     CLOCK = CLOCK + 1
C
C     If the CLOCK is greater than the Simulation time then skip to the
C     end of this module.
C     Conditional IF #16
C
         IF (CLOCK.LE.SIMTIME) THEN
C
C     If the value stored in the vehicle red time array is equal to the
C     clock time then set the Vehicle.Red phase to TRUE
C
            IF (VEHRED(RI).EQ.CLOCK) RED = .TRUE.
```

```
C
C     If the vehicle phase is red
C     Conditional IF #17
C
            IF (RED) THEN
C
C     Set up a DO loop to quickly increment the clock such that the
C     vehicle green phase reappears
C
               DO 4007 KK = 1, MAXVHRED
                  CLOCK = CLOCK + 1
4007           CONTINUE
C
C     Reset the vehicle red phase flag to FALSE
C
               RED = .FALSE.
C
C     Increment the vehicle red phase counter for the array
C
               RI = RI + 1
C
C     Endif for Conditional IF #17
C
            ENDIF
C
C     If the time at which the vehicle arrives is less than or equal to
C     CLOCK then determine how far into the Green phase the signal is at
C     Conditional IF #18
C
            IF (TMVHARV.LE.CLOCK) THEN
C
C     There is a special condition for the first iteration of this
C     portion of the module.  Since the RI counter begins at 1 and
C     stores the first red phase, in order to determine the TIME and the
C     length of the first vehicle green we must have a special
C     consideration.
C     Conditional IF #19
C
               IF (RI.EQ.1) THEN
C
C     The variable TIME is set to the value of CLOCK
C
                  TIME = CLOCK
C
C     The length of the green interval is equal to the time at which the
C     vehicle signal first turned to RED
C
                  THISGR = VEHRED(RI)
C
```

```
C     Otherwise if this is not the first red interval
C
             ELSE
C
C     The variable TIME is equal to the value of CLOCK minus the time at
C     which the previous RED signal began
C
                TIME = CLOCK - VEHRED(RI - 1)
C
C     The length of this green interval is equal to the time of the
C     current RED phase minus the time at which the previous red phase
C     occurred minus the pedestrian green time minus the pedestrian
C     clearance time
C
                THISGR=(VEHRED(RI)-(VEHRED(RI-1)+PEDGREEN+PEDCLR))
C
C     Endif for Conditional IF #19
C
             ENDIF
C
C     The variable CHKTM stores the length of vehicle Green time
C     remaining by subtracting the amount of Green time used from the
C     total amount of Green time available
C
             CHKTM = THISGR - TIME
C
C     Set up the DO loop which will run for the duration of the current
C     vehicle Green interval.  Within this DO loop the vehicles are
C     discharged and the vehicle delays are calculated
C
             DO 4003 J = 1, THISGR
C
C     Set the variable DSCHTM equal to J
C
                DSCHTM = J
C
C     If the CHKTM + DSCHTM is greater than the Length of this green
C     interval then loop back to line labeled 4002.  In other words the
C     vehicle would be crossing the stopline during RED if the condition
C     evaluates to TRUE.  If it does evaluate to TRUE then loop back to
C     increment the clock to get to the next green interval.
C
                IF ((CHKTM+DSCHTM).GT.THISGR) GOTO 4002
C
C     If the CLOCK time plus the DISCHARGE time minus the time at which
C     the previous vehicle discharged is greater than the Saturation
C     Flow headway then continue processing, otherwise jump down to
C     increment the DO loop.  This is conditional IF #20
C
```

```
             IF ((CLOCK+DSCHTM - PREVDIS).GE.SFHDWY) THEN
C
C     Check if the CLOCK minus the time at which the previous vehicle
C     discharged is greater than the Saturation Flow headway.  If the
C     condition evaluates to TRUE then the vehicle does not slow down or
C     stop at the intersection.
C
                IF ((CLOCK - PREVDIS).GE.SFHDWY) DSCHTM = 0
C
C     Calculate the vehicle delay by adding the CLOCK time plus the
C     Discharge Time and subtracting the Vehicle Arrival time.
C
                DELAY = (CLOCK + DSCHTM) - TMVHARV
C
C     Check to see if somehow the calculated delay evaluates to less
C     than zero then set the delay equal to 0.
C
                IF (DELAY.LT.0) DELAY = 0
C
C     Store the vehicle discharge time in the variable PREVDIS to be
C     used in the next iteration of the loop.
C
                PREVDIS = CLOCK + DSCHTM
C
C     Store the vehicle discharge time in the array
C
                VEHICLE(N,3) = TMVHARV
C
C     Store the vehicle discharge time in the array
C
                VEHICLE(N,4) = CLOCK + DSCHTM
C
C     Add the intersection delay to the vehicle delay in the array
C
                VEHICLE(N,7) = VEHICLE(N,7) + DELAY
C
C     Sum up the total vehicle delay
C
                TOTLDELAY = TOTLDELAY + VEHICLE(N,7)
C
C     If the user requested a detailed output from the program then
C     print out the vehicle number, time of arrival, the delay and the
C     time of discharge.
C
                IF (PRNDETL.EQ.'Y') THEN
                   WRITE(6,7771)N,TMVHARV,VEHICLE(N,4),DELAY,
     +                          VEHICLE(N,7)
                ENDIF
C
C     Sum up the intersection delay
C
                DELAYSUM = DELAYSUM + DELAY
C
C     Jump up to line 4001 to increment the vehicle counter
```

```
C
                     GOTO 4001
C
C     Endif for Conditional IF #20
C
                  ENDIF
C
C     End of the DO loop
C
4003           CONTINUE
C
C     Endif for Conditional IF #18
C
            ENDIF
C
C     Jump to Line 4002 to increment the time clock
C
            GOTO 4002
C
C     Endif for Conditional IF #16
C
         ENDIF
C
C     Endif for Conditional IF #15
C
      ENDIF
C
C     Calculate the average delay at this intersection.  The denominator
C     is (N - 1) because this intersection may not process all of the
C     vehicles generated by the first intersection.
C
4444  AVGDELAY = DELAYSUM/(N - 1)
C
C     Calculate the average of the total delay experienced by all of the
C     vehicles.  The total delay includes the delay experienced at
C     intersections 1 and 2.
C
      AVGTOTDELAY = TOTLDELAY/(N - 1)
C
C     Print out the two delays to the file and to the screen
C
      WRITE(*,7772) AVGDELAY,AVGTOTDELAY
      WRITE(6,7772) AVGDELAY,AVGTOTDELAY
C
C     Reset the Vehicle Counter to match the maximum number of vehicles
C     that proceeded through the PEDXING.  This is done because not all
C     of the vehicles discharged from Intersection #1 proceeded through
C     the pedestrian crossing within the Simulation Time specified
C
```

```
      VHCNTR = N - 1
C
C
C     *****************************************************************
C
C     Intersection #3 Delay Calculations
C
C     Now perform the same delay calculations for the next intersection by
C     taking the results from the first intersection (stored in the VEH
C     array) and utilizing them in the second intersection
C
C     *****************************************************************
C
C     Initialize variables
      PREVDIS = 0
      DELAYSUM = 0
      TOTLDELAY = 0
      SUM2 = 0
      AVGDELAY = 0
      TMVHARV = 0
      N = 0
C
C     Increment the vehicle counter
C
5000  N = N + 1
C
C     If N is less than or equal to the number of vehicles generated at
C     the first intersection then continue processing otherwise jump
C     down to the end of this module
C     Conditional IF #21
C
      IF (N.LE.VHCNTR) THEN
C
C     The time that the vehicle arrives is equal to the time of
C     discharge from Intersection #2 plus the travel time from
C     intersection 2 to intersection 3
C
         TMVHARV = VEHICLE(N,4) + TRAVEL2
C
C     Increment the time clock
C
5001     CLOCK = CLOCK + 1
C
C     If the CLOCK is less than the Simulation Time then continue
C     processing, otherwise skip down to near the end of the module
C     Conditional IF #22
C
         IF (CLOCK.LE.SIMTIME) THEN
C
```

```
C     IF the Vehicle Time of arrival is greater than the clock time then
C     loop back to increment the clock
C
            IF (TMVHARV.GT.CLOCK) GOTO 5001
C
C     If the clock is less than the vehicle red time the set the clock
C     equal to the vehicle arrival time
C
            IF (CLOCK.LT.VHREDTM2) CLOCK = TMVHARV
C
C     Determine which cycle the signal is at, remembering to include the
C     signal offset time
C
            CYCLE = (CLOCK-OFFSET2)/CYCLETM2
C
C     Determine the integer value of the cycle by truncating the value
C     of CYCLE
C
            NCYCLE = INT(CYCLE)
C
C     The time into the phase is equal to the CLOCK minus the OFFSET
C     minus the number of cycles multiplied by the cycle time
C
            TIME = (CLOCK-OFFSET2) - (NCYCLE * CYCLETM2)
C
C     The amount of time remaining in the Green phase is equal to TIME
C     minus the Vehicle Red Time
C
            CHKTM = TIME - VHREDTM2
C
C     If the value of CHKTM is greater than or equal to 0 then the
C     signal is green and the rest of the calculations may proceed
C     Conditional IF #23
C
            IF (CHKTM.GE.0) THEN
C
C     This DO loop is the main processing portion of the module.  The
C     counter, J, can go from 1 to Vehicle Green Time.
C
               DO 5002 J = 1,VHGRTM2
C
C     Set the variable DSCHTM equal to J
C
                  DSCHTM = J
C
C     If the CHKTM + DSCHTM is greater than the Vehicle Green Time then
C     loop back to line labeled 5001.  In other words the vehicle would
C     be crossing the stopline during RED if the condition evaluated to
C     TRUE.  If it does evaluate to TRUE then loop back to increment the
```

```
C     clock to get to the next green interval.
C
                  IF ((CHKTM+DSCHTM).GT.VHGRTM2) GOTO 5001
C
C     If the CLOCK time plus the DISCHARGE time minus the time at which
C     the previous vehicle discharged is greater than the Saturation
C     Flow headway then continue processing, otherwise jump down to
C     increment the DO loop.  This is conditional IF #24
C
               IF ((CLOCK+DSCHTM - PREVDIS).GE.SFHDWY) THEN
C
C     Check if the CLOCK minus the time at which the previous vehicle
C     discharged is greater than the Saturation Flow headway.  If the
C     condition evaluates to TRUE then the vehicle does not slow down or
C     stop at the intersection.
C
                  IF ((CLOCK - PREVDIS).GE.SFHDWY) DSCHTM = 0
C
C     Calculate the vehicle delay by adding the CLOCK time plus the
C     Discharge Time and subtracting the Vehicle Arrival time.
C
                     DELAY = (CLOCK + DSCHTM) - TMVHARV
C
C     Check to see if somehow the calculated delay evaluates to less
C     than zero then set the delay equal to 0.
C
                     IF (DELAY.LT.0) DELAY = 0
C
C     Store the vehicle discharge time in the variable PREVDIS to be
C     used in the next iteration of the loop.
C
                     PREVDIS = CLOCK + DSCHTM
C
C     Store the vehicle ARRIVAL time in the array
C
                     VEHICLE(N,5) = TMVHARV
C
C     Store the vehicle discharge time in the array
C
                     VEHICLE(N,6) = CLOCK + DSCHTM
C
C     Store the vehicle delay in the array
C
                     VEHICLE(N,7) = VEHICLE(N,2) + DELAY
C
C     Sum up the total vehicle delay
C
                     TOTLDELAY = TOTLDELAY + VEHICLE(N,7)
C
```

```
C     If the user requested a detailed output from the program then
C     print out the vehicle number, time of arrival, the delay and the
C     time of discharge.
C
                     IF (PRNDETL.EQ.'Y') THEN
                        WRITE(6,7771)N,TMVHARV,VEHICLE(N,6),DELAY,
     +                               VEHICLE(N,7)
                     ENDIF
C
C     Sum up the intersection delay
C
                     DELAYSUM = DELAYSUM + DELAY
C
C     Jump to line 5000 to increment the vehicle counter
C
                     GOTO 5000
C
C     Endif for Conditional IF #24
C
                  ENDIF
C
C     End of the DO loop
C
5002           CONTINUE
C
C     Endif for Conditional IF #23
C
            ENDIF
C
C     Jump to line 5001 to increment the time clock
C
            GOTO 5001
C
C     Endif for Conditional IF #22
C
         ENDIF
C
C     Endif for conditional IF #21
C
      ENDIF
C
C     Calculate the average intersection delay
C
5555  AVGDELAY = DELAYSUM/(N-1)
C
C     Calculate the average total delay
C
      AVGTOTDELAY = TOTLDELAY/(N-1)
C
```

```
C     Write the two delays to the file and to the screen
C
      WRITE(*,7772) AVGDELAY,AVGTOTDELAY
      WRITE(6,7772) AVGDELAY,AVGTOTDELAY
C
C
C     ****** TIME SPACE DIAGRAM PLOTTING  *********
C
C
C     If the user wants the Time Space diagram then print out the TSD
C     plot Conditional IF #25
C
      IF (TSD.EQ.'Y'.OR.TSD.EQ.'y') THEN
C
C     The maximum number of vehicles that can be displayed on the TSD is
C     equal to the number of vehicles that passed through Intersection
C     #3.
C
         MAX = N - 1
C
C     Check to see if the user specified a vehicle number greater than
C     the number of vehicles that passed through Intersection #3.  If
C     the number is greater then reset it to MAX.
C
         IF(TSDEND.GT.MAX)TSDEND = MAX
C
C     The maximum time to plot on the TSD is equal to the discharge time
C     of the TSDEND vehicle at intersection #2 plus two seconds
C
         ENDTIME = VEHICLE(TSDEND,6) + 2
C
C     The beginning or start time of the TSD plot is equal to the
C     arrival time of the TSDSTART vehicle at intersection #1 minus 2
C     seconds
C
         STARTTIME = VEHICLE(TSDSTART,1) - 2
C
C     Print out the header information for the TSD plot
C
         WRITE(8,8031)
8031     FORMAT(//,25X,'PEDXING PROGRAM - TIME SPACE DIAGRAM PLOT',//)
         WRITE(8,8030)
8030     FORMAT(14X,'INTERSECTION #1',36X,'CROSSWALK',37X,
     +          'INTERSECTION #2',/, 6X,'TIME',3X,'ARRIVE',5X,'DEPART',
     +          30X,'ARRIVE',7X,'DEPART',30X,'ARRIVE',7X,'DEPART')
C
C     Set up the DO loop to process all of the vehicles to plot them on
C     the TSD.  All of the loops have negative increments in order to
C     obtain a TSD that has time increasing on the vertical axis and
```

```
C     distance increasing on the horizontal axis.  The plot will begin
C     at the top and work its way down
C
         DO 8001 NTIME = ENDTIME, STARTTIME, -1
C
C     Initialise all of the flags for each iteration of the loop
C
            FLAG1 = .FALSE.
            FLAG2 = .FALSE.
            FLAG3 = .FALSE.
            FLAG4 = .FALSE.
            FLAG5 = .FALSE.
            FLAG6 = .FALSE.
C
C
C     ***********  ARRIVALS  *************
C
C     Using a DO loop check through all of the vehicle ARRIVAL times at
C     intersection #1
C     DO Loop #2
C
            DO 8002 NN=TSDEND,TSDSTART,-1
C
C     If a vehicle arrival time is equal to the DO loop time then set
C     the FLAG to TRUE
C
               IF (VEHICLE(NN,1).EQ.NTIME)FLAG1=.TRUE.
C
C     As soon as the FLAG is set to true jump to line 8003 to print out
C     information on the TSD plot
C
               IF (FLAG1) GOTO 8003
C
C     The continue statement for DO loop #2
C
8002        CONTINUE
C
C     If the FLAG has been set to true then print out the TIME, the
C     vehicle number and the flag for Through or On-turn vehicle.  If
C     the FLAG is FALSE then an asterisk will be printed in the
C     intersection #1 arrival column
C
8003        IF (FLAG1) THEN
               WRITE(8,8004)NTIME,NN,VEHICLE(NN,8)
8004           FORMAT(5X,I5,1X,I5,A1,\)
            ELSE
               WRITE(8,8005)NTIME
8005           FORMAT(5X,I5,6X,'*',\)
            ENDIF
```

```
C
C
C     ***********  DEPARTURES  *************
C
C     Using a DO loop check through all of the vehicle DEPARTURE times
C     for intersection #1
C     DO Loop #3
C
            DO 8006 NN=TSDEND,TSDSTART,-1
C
C     If a vehicle departure time is equal to the DO loop time then set
C     the FLAG to TRUE
C
               IF (VEHICLE(NN,2).EQ.NTIME)FLAG2=.TRUE.
C
C     As soon as the FLAG is set to true jump to line 8007 to print out
C     information on the TSD plot
C
               IF (FLAG2) GOTO 8007
C
C     The continue statement for DO loop #3
C
8006        CONTINUE
C
C     If the FLAG is set to TRUE then print out the vehicle number and
C     either the 'T' or 'O' as required.  If the FLAG is FALSE then
C     print out an asterisk.
C
8007        IF (FLAG2) THEN
               WRITE(8,8008)NN,VEHICLE(NN,8)
8008           FORMAT(TR7,I5,A1,\)
            ELSE
               WRITE(8,8009)
8009           FORMAT(TR12,'*',\)
            ENDIF
C
C
C     ***********  ARRIVALS  *************
C
C
            DO 8010 NN=TSDEND,TSDSTART,-1
C
C     If a vehicle arrival time is equal to the DO loop time then set
C     the FLAG to TRUE
C
               IF (VEHICLE(NN,3).EQ.NTIME)FLAG3=.TRUE.
C
C     As soon as the FLAG is set to true jump to line 8011 to print out
C     information on the TSD plot
```

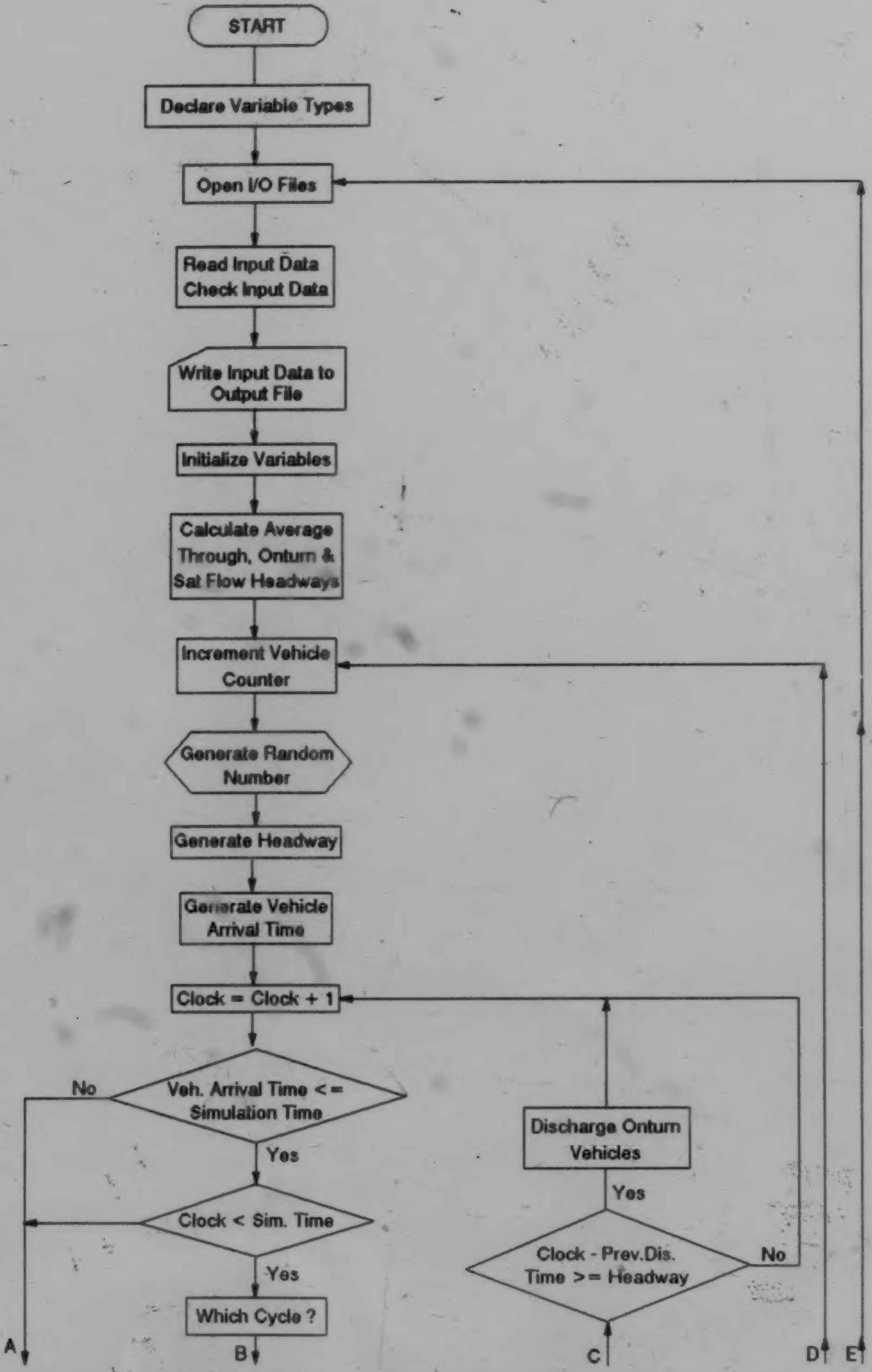
```
C
               IF (FLAG3) GOTO 8011
C
C     The continue statement for DO loop #4
C
8010        CONTINUE

C
C     If the FLAG is set to TRUE then print out the vehicle number and
C     either the 'T' or 'O' as required.  If the FLAG is FALSE then
C     print out an asterisk.
C
8011        IF (FLAG3) THEN
               WRITE(8,8012)NN,VEHICLE(NN,8)
8012           FORMAT(TR30,I5,A1,\)
            ELSE
               WRITE(8,8013)
8013           FORMAT(TR35,'*',\)
            ENDIF
C
C
C     ***********  DEPARTURES  *************
C

            DO 8014 NN=TSDEND,TSDSTART,-1
C
C     If a vehicle departure time is equal to the DO loop time then set
C     the FLAG to TRUE
C
               IF (VEHICLE(NN,4).EQ.NTIME)FLAG4=.TRUE.
C
C     As soon as the FLAG is set to true jump to line 8015 to print out
C     information on the TSD plot
C
               IF (FLAG4) GOTO 8015
C
C     The continue statement for DO loop #5
C
8014        CONTINUE
C
C     If the FLAG is set to TRUE then print out the vehicle number and
C     either the 'T' or 'O' as required.  If the FLAG is FALSE then
C     print out an asterisk.
C
8015        IF (FLAG4) THEN
               WRITE(8,8016)NN,VEHICLE(NN,8)
8016           FORMAT(TR7,I5,A1,\)
            ELSE
               WRITE(8,8017)
```

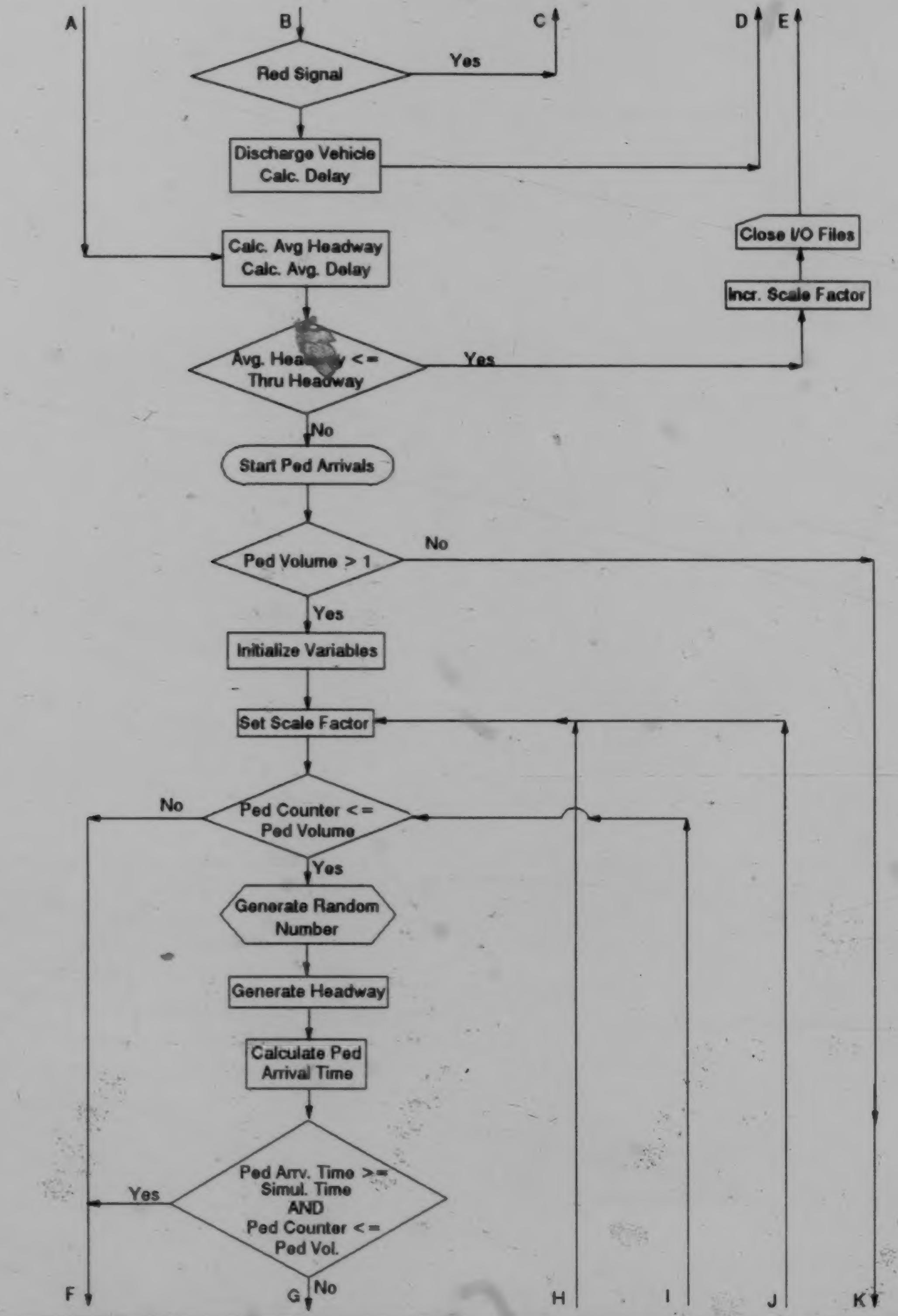
```
8017         FORMAT(TR12,'*',\)
          ENDIF
C
C
C     ***********  ARRIVALS  *************
C
          DO 8018 NN=TSDEND,TSDSTART,-1
C
C     If a vehicle arrival time is equal to the DO loop time then set
C     the FLAG to TRUE
C
             IF (VEHICLE(NN,5).EQ.NTIME)FLAG5=.TRUE.
C
C     As soon as the FLAG is set to true jump to line 8019 to print out
C     information on the TSD plot
C
             IF (FLAG5) GOTO 8019
C
C     The continue statement for DO loop #6
C
8018      CONTINUE
C
C     If the FLAG is set to TRUE then print out the vehicle number and
C     either the 'T' or 'O' as required.  If the FLAG is FALSE then
C     print out an asterisk.
C
8019      IF (FLAG5) THEN
             WRITE(8,8020)NN,VEHICLE(NN,8)
8020         FORMAT(TR30,I5,A1,\)
          ELSE
             WRITE(8,8021)
8021         FORMAT(TR35,'*',\)
          ENDIF
C
C
C     ***********  DEPARTURES  *************
C
          DO 8022 NN=TSDEND,TSDSTART,-1
C
C     If a vehicle departure time is equal to the DO loop time then set
C     the FLAG to TRUE
C
             IF (VEHICLE(NN,6).EQ.NTIME)FLAG6=.TRUE.
C
C     As soon as the FLAG is set to true jump to line 8023 to print out
C     information on the TSD plot
C
             IF (FLAG6) GOTO 8023
C
```

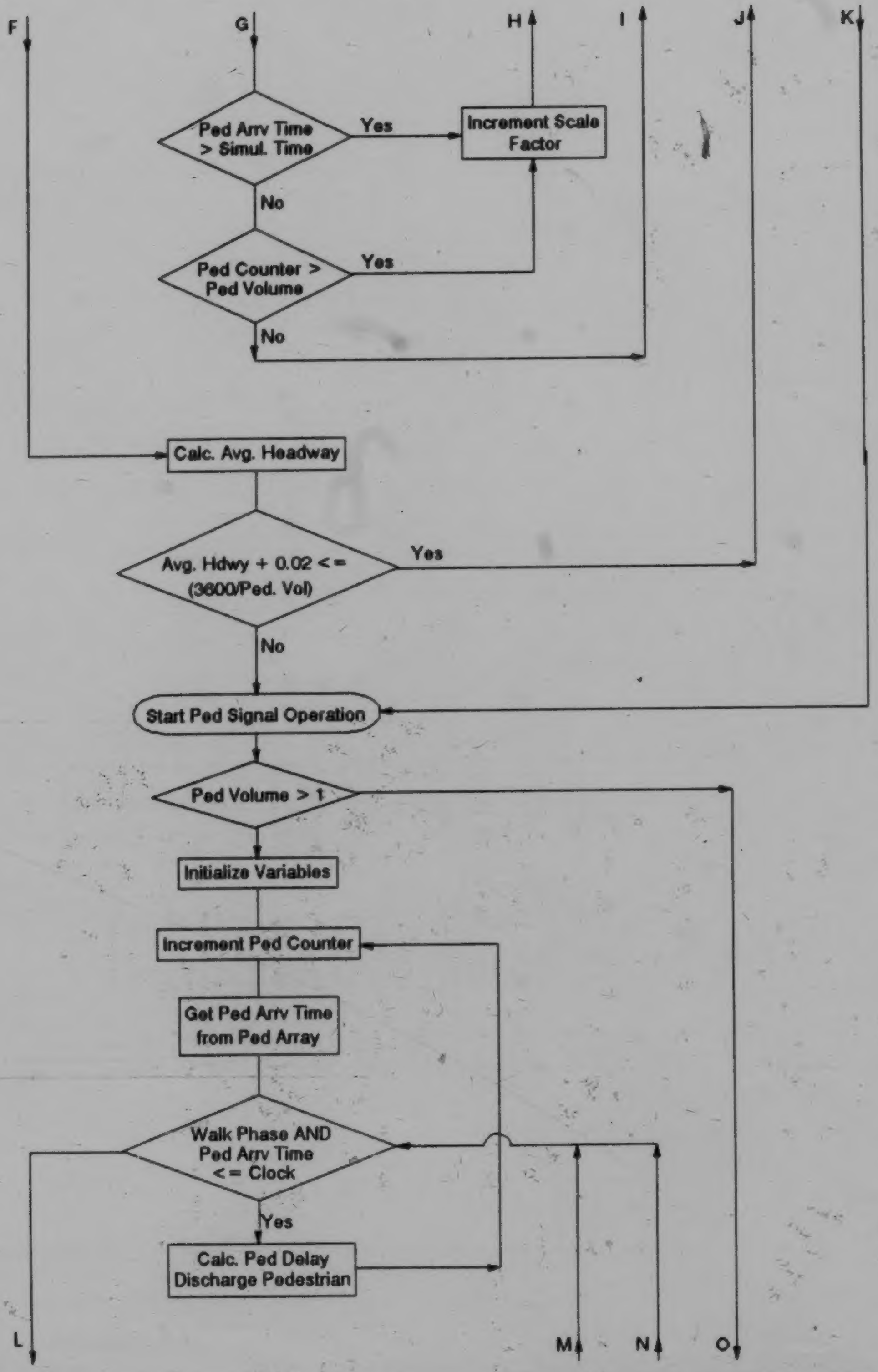
```
C     The continue statement for DO loop #7
C
8022        CONTINUE
C
C     If the FLAG is set to TRUE then print out the vehicle number and
C     either the 'T' or 'O' as required.  If the FLAG is FALSE then
C     print out an asterisk.
C
8023        IF (FLAG6) THEN
               WRITE(8,8024)NN,VEHICLE(NN,8)
8024           FORMAT(TR7,I5,A1)
            ELSE
               WRITE(8,8025)
8025           FORMAT(TR12,'*')
            ENDIF
C
C     The continue statement for DO loop #1
C
8001     CONTINUE
C
C     Endif for Conditional IF #25
C
      ENDIF
C
C     Ask if the user wishes to rerun the program and wait for a
C     response.
C
      WRITE(*,5006)
5006  FORMAT(2X,'Rerun the Program (y/n) ?')
      READ(*,5007)ANS1
5007  FORMAT(A1)
      IF (ANS1.EQ.'y'.OR.ANS1.EQ.'Y')GOTO 1001
C
C     Format statements that are used by a number of WRITE calls spread
C     throughout the program
C
7771  FORMAT(1X,'Vehicle=',I5,2X,'Arrive=',I5,2X,'Depart=',I5,
     +       2X,'Int.Delay=',I5,2X,'Tot.Delay=',I5)
7772  FORMAT(2X,'Average Intersection Vehicle Delay = ',F6.2,/,
     +       2X,'Average Total Vehicle Delay        = ',F6.2)
7773  FORMAT(2X,'Ped=',I5,2X,'Arrive=',I5,2X,'Depart=',I5,
     +       2X,'Delay=',I5)
7774  FORMAT(2X,'Veh Red at Time = ',I6,)
7775  FORMAT(2X,'Side Street Traffic',5X,'Vehicle=',I5,2X,'Disch=',I5)
7776  FORMAT(2X,'Side Street Traffic',5X,'Vehicle=',I5,
     +       2X,'Disch=',I5)

      STOP
      END
```

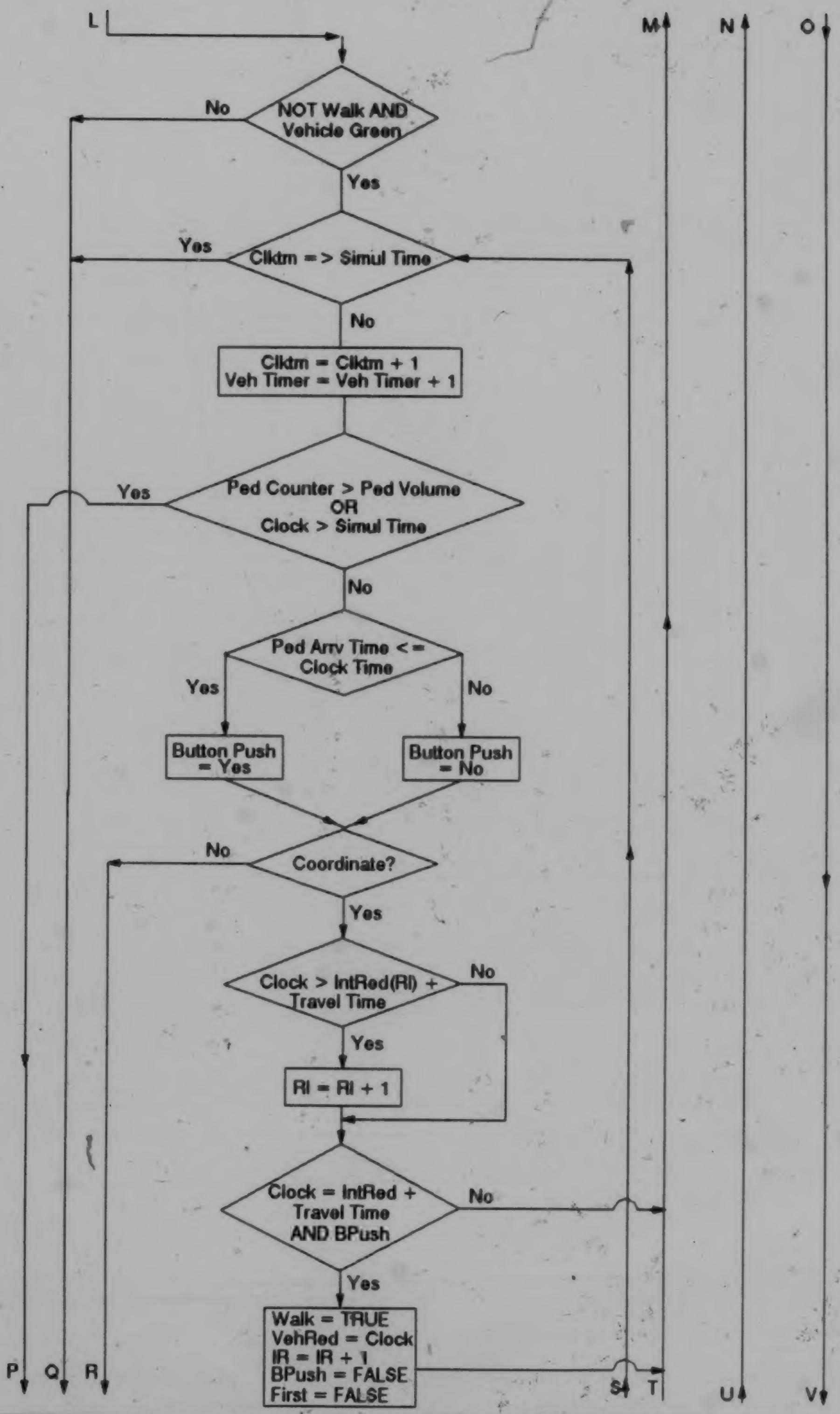
```
C
C     This random number generator was obtained from:
C
C     FORTRAN 77 FOR HUMANS, 3rd Edition
C     West Publishing Co., St. Paul, MN, USA
C     pp. 418-419
C
C     Random Number Generator:  0.0 < RANF < 1.0
C     Value Delivered = Sample from uniform variate on (0,1) interval
C     Instructions: Call first with a non-zero seed to start "Random"
C                   sequence.  Subsequent calls use SEED = 0
C
C     REAL FUNCTION RNDMFNC
      REAL FUNCTION RNDMFNC(SEED)
      INTEGER SEED
      DOUBLE PRECISION RNGMUL,RNGMOD,RNGNUM
      SAVE RNGMUL,RNGMOD, RNGNUM
      DOUBLE PRECISION DMOD
      IF (SEED.NE.0) THEN
         RNGMOD = 2.0D0
         N = 1
100      IF ((1.0D0+RNGMOD).EQ.RNGMOD) GO TO 200
            N = N + 1
            RNGMOD = RNGMOD*2.0D0
            GO TO 100
200      M = N/2
         RNGMOD = 2.0D0**M
         RNGMUL = DBLE(AINT((SQRT(5.0)-1.0)*(REAL(RNGMOD)/8.0)+0.5))
         RNGMUL = RNGMUL - MOD(RNGMUL,8.0D0) + 3.0D0
         RNGNUM = 2 * ABS(SEED/2) + 1
      ENDIF
      RNGNUM = DMOD(RNGMUL*RNGNUM,RNGMOD)
      RNDMFNC = REAL(RNGNUM/RNGMOD)
      RETURN
      END
```

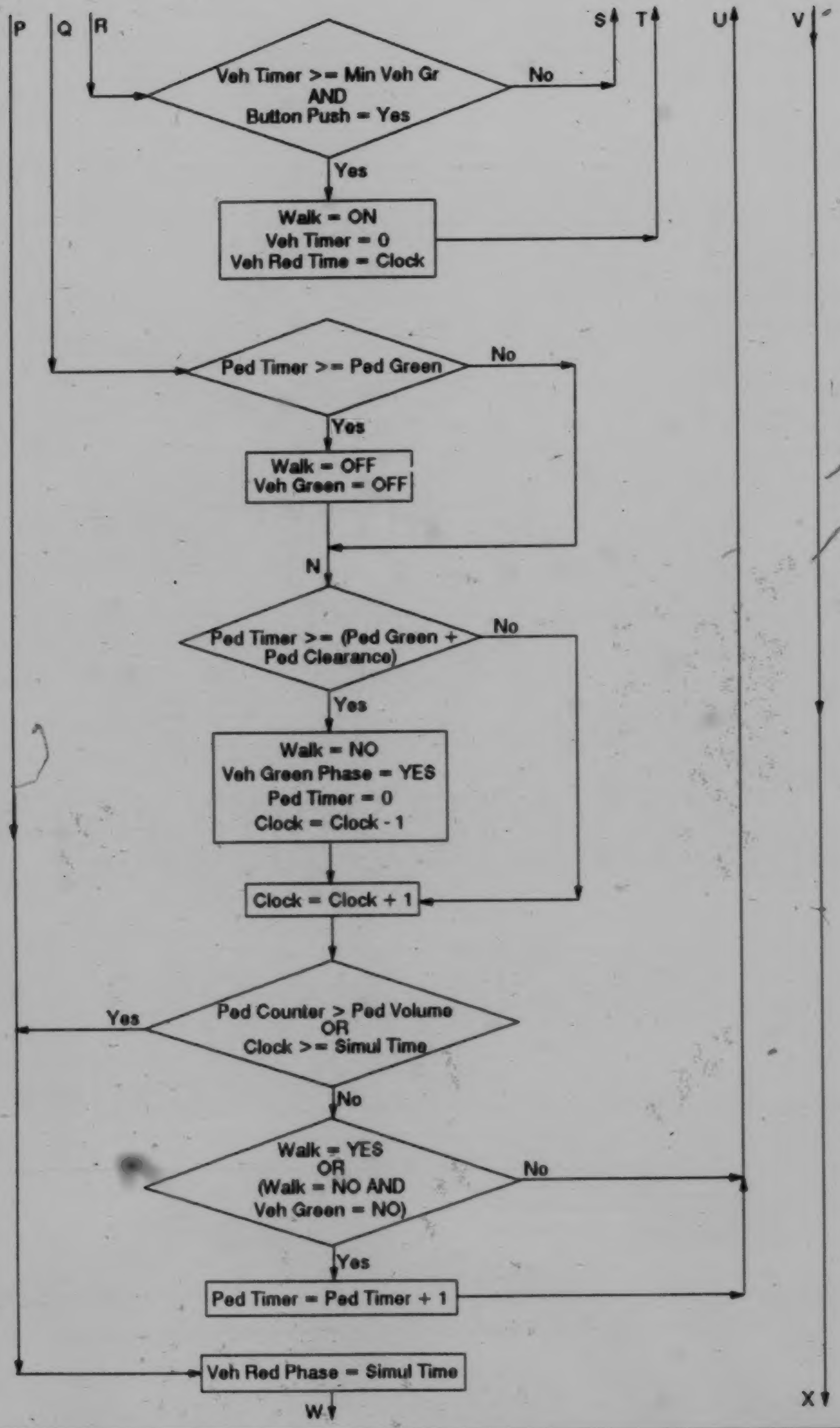
APPENDIX B

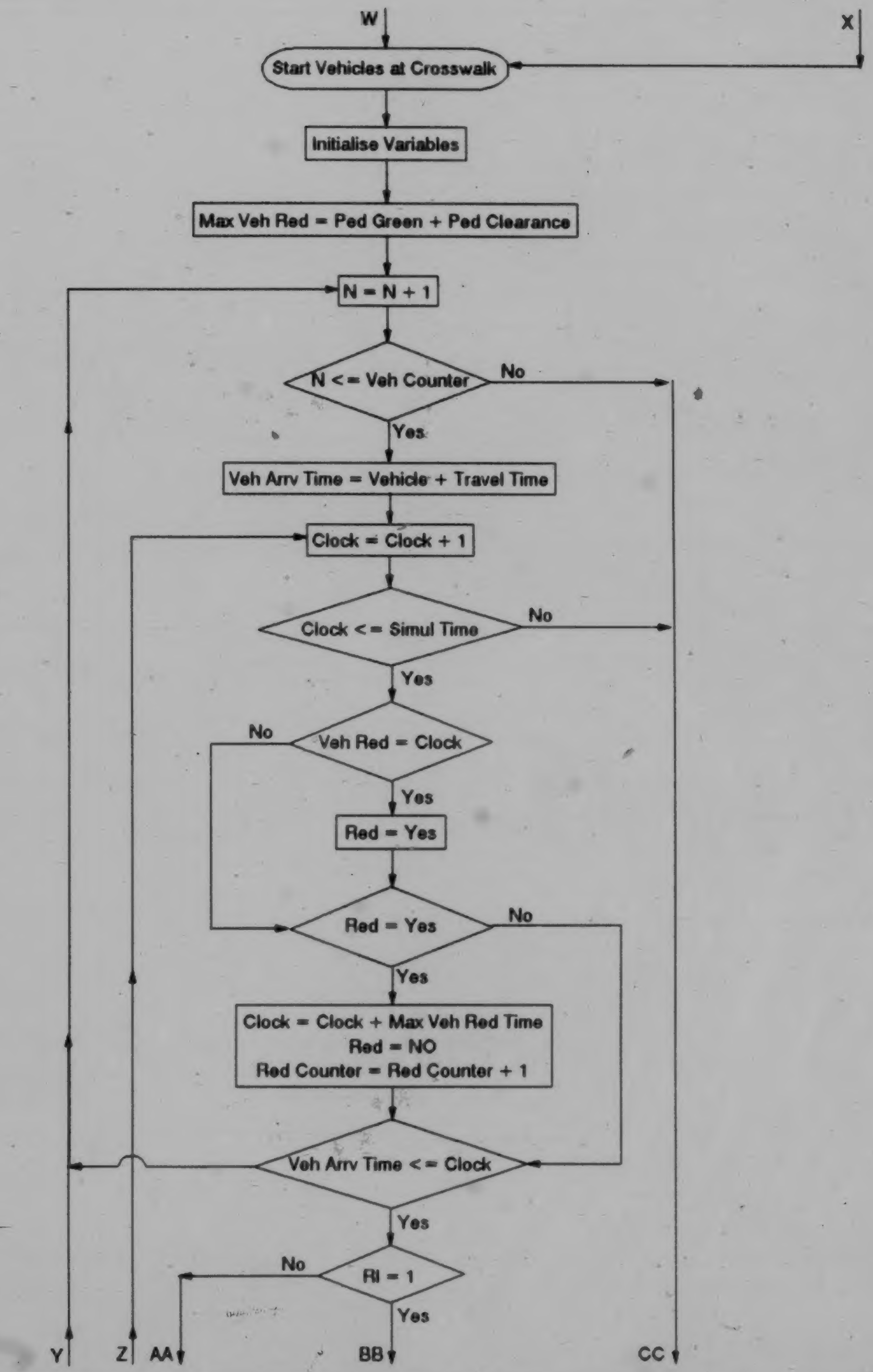

START
Declare Variable Types
Open I/O Files
Read Input Data
Check Input Data
Write Input Data to Output File
Initialize Variables
Calculate Average Through, Onturn & Sat Flow Headways
Increment Vehicle Counter
Generate Random Number
Generate Headway
Generate Vehicle Arrival Time
Clock = Clock + 1
Veh. Arrival Time <= Simulation Time
No
Yes
Clock < Sim. Time
Yes
Which Cycle ?
Discharge Onturn Vehicles
Yes
Clock - Prev.Dis. Time >= Headway
No
A
B
C
D
E

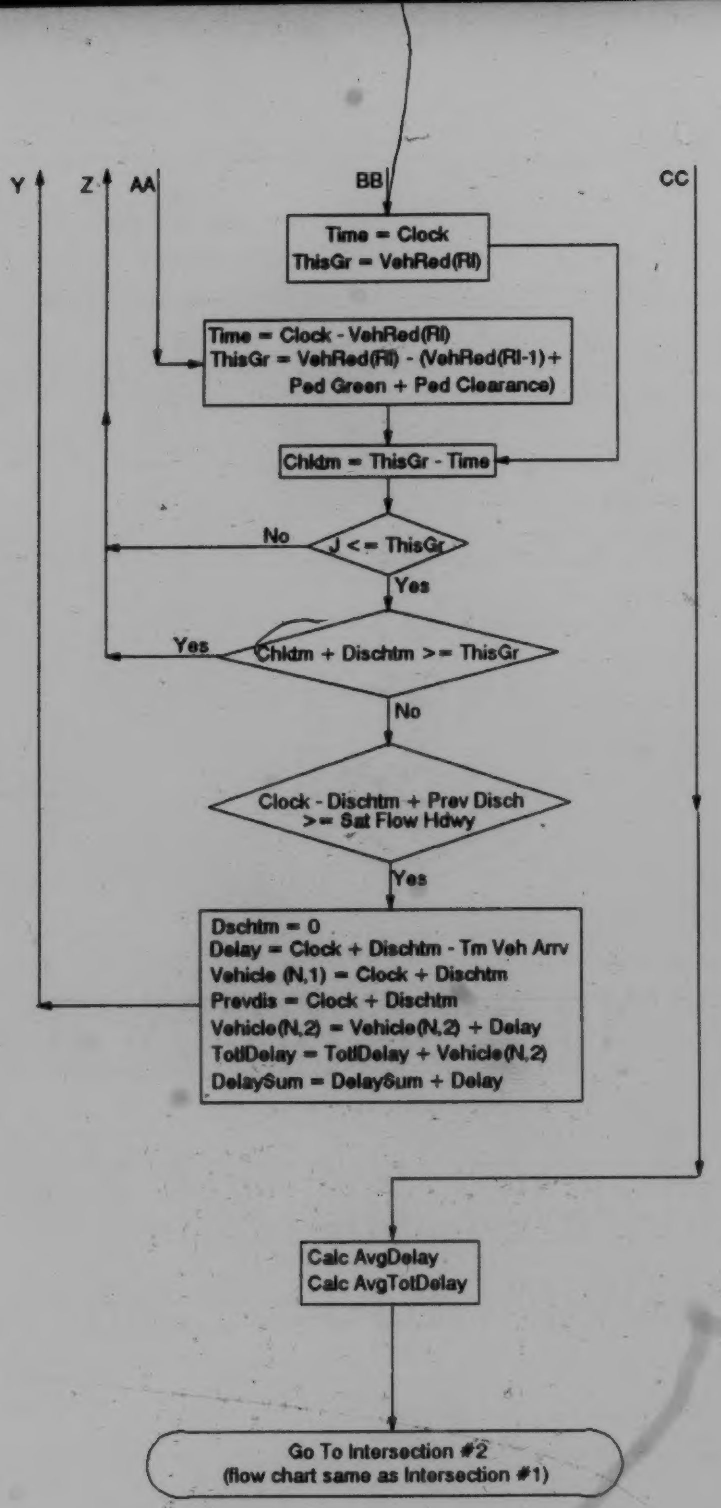

A
B
C
D
E
Red Signal
Yes
Discharge Vehicle
Calc. Delay
Calc. Avg Headway
Calc. Avg. Delay
Close I/O Files
Incr. Scale Factor
Avg. Hea[illegible]y <=
Thru Headway
Yes
No
Start Ped Arrivals
Ped Volume > 1
No
Yes
Initialize Variables
Set Scale Factor
No
Ped Counter <=
Ped Volume
Yes
Generate Random
Number
Generate Headway
Calculate Ped
Arrival Time
Yes
Ped Arrv. Time >=
Simul. Time
AND
Ped Counter <=
Ped Vol.
No
F
G
H
I
J
K


F
G
H
I
J
K
Ped Arrv Time > Simul. Time
Yes
Increment Scale Factor
No
Ped Counter > Ped Volume
Yes
No
Calc. Avg. Headway
Avg. Hdwy + 0.02 <= (3600/Ped. Vol)
Yes
No
Start Ped Signal Operation
Ped Volume > 1
Initialize Variables
Increment Ped Counter
Get Ped Arrv Time from Ped Array
Walk Phase AND Ped Arrv Time <= Clock
Yes
Calc. Ped Delay Discharge Pedestrian
L
M
N
O


L
M
N
O
NOT Walk AND Vehicle Green
No
Yes
Clktm => Simul Time
Yes
No
Clktm = Clktm + 1
Veh Timer = Veh Timer + 1
Ped Counter > Ped Volume OR Clock > Simul Time
Yes
No
Ped Arrv Time <= Clock Time
Yes
No
Button Push = Yes
Button Push = No
Coordinate?
No
Yes
Clock > IntRed(RI) + Travel Time
No
Yes
RI = RI + 1
Clock = IntRed + Travel Time AND BPush
No
Yes
Walk = TRUE
VehRed = Clock
IR = IR + 1
BPush = FALSE
First = FALSE
P
Q
R
S
T
U
V


P
Q
R
S
T
U
V
Veh Timer >= Min Veh Gr AND Button Push = Yes
No
Yes
Walk = ON
Veh Timer = 0
Veh Red Time = Clock
Ped Timer >= Ped Green
No
Yes
Walk = OFF
Veh Green = OFF
N
Ped Timer >= (Ped Green + Ped Clearance)
No
Yes
Walk = NO
Veh Green Phase = YES
Ped Timer = 0
Clock = Clock - 1
Clock = Clock + 1
Ped Counter > Ped Volume OR Clock >= Simul Time
Yes
No
Walk = YES OR (Walk = NO AND Veh Green = NO)
No
Yes
Ped Timer = Ped Timer + 1
Veh Red Phase = Simul Time
W
X


W
X
Start Vehicles at Crosswalk
Initialise Variables
Max Veh Red = Ped Green + Ped Clearance
N = N + 1
N < = Veh Counter
No
Yes
Veh Arrv Time = Vehicle + Travel Time
Clock = Clock + 1
Clock < = Simul Time
No
Yes
No
Veh Red = Clock
Yes
Red = Yes
Red = Yes
No
Yes
Clock = Clock + Max Veh Red Time
Red = NO
Red Counter = Red Counter + 1
Veh Arrv Time < = Clock
Yes
No
RI = 1
Yes
Y
Z
AA
BB
CC


Y
Z
AA
BB
CC
Time = Clock
ThisGr = VehRed(RI)
Time = Clock - VehRed(RI)
ThisGr = VehRed(RI) - (VehRed(RI-1) + Ped Green + Ped Clearance)
Chktm = ThisGr - Time
No
J <= ThisGr
Yes
Yes
Chktm + Dischtm >= ThisGr
No
Clock - Dischtm + Prev Disch >= Sat Flow Hdwy
Yes
Dschtm = 0
Delay = Clock + Dischtm - Tm Veh Arrv
Vehicle (N,1) = Clock + Dischtm
Prevdis = Clock + Dischtm
Vehicle(N,2) = Vehicle(N,2) + Delay
TotlDelay = TotlDelay + Vehicle(N,2)
DelaySum = DelaySum + Delay
Calc AvgDelay
Calc AvgTotDelay
Go To Intersection #2
(flow chart same as Intersection #1)

APPENDIX C

```
PEDESTRIAN CROSSING EVALUATION


     Through traffic volume (pcu/h)                :   185.
     Side street on turn traffic volume            :   130.
     Stopline saturation flow (pcu/h*gr)           :  1550.
     Duration of simulation (minutes)              :    60
     Seed Number (odd three digit)                 :   815
     Vehicle Red Interval #1 (seconds)             :    51.
     Vehicle Green Interval #1 (seconds)           :    24.
     Vehicle Red Interval #2 (seconds)             :    32.
     Vehicle Green Interval #2 (seconds)           :    28.
     Pedestrian volume (peds/h)                    :   150
     Pedestrian green time (seconds)               :     8
     Pedestrian clearance time (seconds)           :    17
     Travel time (Int.1 to ped crossing, seconds) :    10
     Travel time (Ped crossing to Int.2, seconds) :    10
     Signal Offset (seconds)                       :    37
     Intersection #1 cycle time (seconds)          :    75
     Intersection #2 cycle time (seconds)          :    60
     Minimum vehicle green time at ped X-ing (sec):    40
     PEDXING coordinated with signals (Y/N)        :     N
     Print the Time Space Diagram (Y/N)            :     Y
     Produce detailed report                       :     Y


Vehicle=    4  Arrive=   12  Depart=   51  Int.Delay=    0  Tot.Delay=   39
Vehicle=    5  Arrive=   35  Depart=   53  Int.Delay=    0  Tot.Delay=   18
Vehicle=    6  Arrive=   39  Depart=   55  Int.Delay=    0  Tot.Delay=   16
Vehicle=    7  Arrive=   69  Depart=   69  Int.Delay=    0  Tot.Delay=    0
Vehicle=   11  Arrive=   95  Depart=  126  Int.Delay=    0  Tot.Delay=   31
Vehicle=   12  Arrive=   99  Depart=  128  Int.Delay=    0  Tot.Delay=   29
Vehicle=   13  Arrive=  132  Depart=  132  Int.Delay=    0  Tot.Delay=    0
Vehicle=   17  Arrive=  151  Depart=  201  Int.Delay=    0  Tot.Delay=   50
Vehicle=   18  Arrive=  174  Depart=  203  Int.Delay=    0  Tot.Delay=   29
Vehicle=   19  Arrive=  180  Depart=  205  Int.Delay=    0  Tot.Delay=   25
Vehicle=   20  Arrive=  192  Depart=  207  Int.Delay=    0  Tot.Delay=   15
Vehicle=   21  Arrive=  199  Depart=  209  Int.Delay=    0  Tot.Delay=   10
Vehicle=   22  Arrive=  221  Depart=  221  Int.Delay=    0  Tot.Delay=    0
Vehicle=   26  Arrive=  262  Depart=  276  Int.Delay=    0  Tot.Delay=   14
Vehicle=   27  Arrive=  274  Depart=  278  Int.Delay=    0  Tot.Delay=    4
Vehicle=   28  Arrive=  293  Depart=  293  Int.Delay=    0  Tot.Delay=    0
Vehicle=   32  Arrive=  306  Depart=  351  Int.Delay=    0  Tot.Delay=   45
Vehicle=   33  Arrive=  309  Depart=  353  Int.Delay=    0  Tot.Delay=   44
Vehicle=   34  Arrive=  330  Depart=  355  Int.Delay=    0  Tot.Delay=   25
Vehicle=   35  Arrive=  332  Depart=  357  Int.Delay=    0  Tot.Delay=   25
Vehicle=   36  Arrive=  342  Depart=  359  Int.Delay=    0  Tot.Delay=   17
Vehicle=   37  Arrive=  347  Depart=  361  Int.Delay=    0  Tot.Delay=   14
```

```
Vehicle=   38  Arrive=  356  Depart=  363  Int.Delay=     0  Tot.Delay=    7
Vehicle=   42  Arrive=  388  Depart=  426  Int.Delay=     0  Tot.Delay=   38
Vehicle=   43  Arrive=  395  Depart=  428  Int.Delay=     0  Tot.Delay=   33
Vehicle=   44  Arrive=  427  Depart=  430  Int.Delay=     0  Tot.Delay=    3
Vehicle=   45  Arrive=  448  Depart=  448  Int.Delay=     0  Tot.Delay=    0
Vehicle=   49  Arrive=  482  Depart=  501  Int.Delay=     0  Tot.Delay=   19
Vehicle=   53  Arrive=  528  Depart=  576  Int.Delay=     0  Tot.Delay=   48
Vehicle=   54  Arrive=  554  Depart=  578  Int.Delay=     0  Tot.Delay=   24
Vehicle=   55  Arrive=  558  Depart=  580  Int.Delay=     0  Tot.Delay=   22
Vehicle=   56  Arrive=  582  Depart=  582  Int.Delay=     0  Tot.Delay=    0
Vehicle=   60  Arrive=  622  Depart=  651  Int.Delay=     0  Tot.Delay=   29
Vehicle=   61  Arrive=  630  Depart=  653  Int.Delay=     0  Tot.Delay=   23
Vehicle=   62  Arrive=  632  Depart=  655  Int.Delay=     0  Tot.Delay=   23
Vehicle=   63  Arrive=  642  Depart=  657  Int.Delay=     0  Tot.Delay=   15
Vehicle=   64  Arrive=  647  Depart=  659  Int.Delay=     0  Tot.Delay=   12
Vehicle=   65  Arrive=  663  Depart=  663  Int.Delay=     0  Tot.Delay=    0
Vehicle=   66  Arrive=  672  Depart=  672  Int.Delay=     0  Tot.Delay=    0
Vehicle=   70  Arrive=  707  Depart=  726  Int.Delay=     0  Tot.Delay=   19
Vehicle=   71  Arrive=  711  Depart=  728  Int.Delay=     0  Tot.Delay=   17
Vehicle=   72  Arrive=  729  Depart=  730  Int.Delay=     0  Tot.Delay=    1
Vehicle=   73  Arrive=  732  Depart=  732  Int.Delay=     0  Tot.Delay=    0
Vehicle=   74  Arrive=  743  Depart=  743  Int.Delay=     0  Tot.Delay=    0
Vehicle=   78  Arrive=  799  Depart=  801  Int.Delay=     0  Tot.Delay=    2
Vehicle=   79  Arrive=  808  Depart=  808  Int.Delay=     0  Tot.Delay=    0
Vehicle=   80  Arrive=  814  Depart=  814  Int.Delay=     0  Tot.Delay=    0
Vehicle=   84  Arrive=  834  Depart=  876  Int.Delay=     0  Tot.Delay=   42
Vehicle=   88  Arrive=  907  Depart=  951  Int.Delay=     0  Tot.Delay=   44
Vehicle=   89  Arrive=  918  Depart=  953  Int.Delay=     0  Tot.Delay=   35
Vehicle=   90  Arrive=  927  Depart=  955  Int.Delay=     0  Tot.Delay=   28
Vehicle=   91  Arrive=  930  Depart=  957  Int.Delay=     0  Tot.Delay=   27
Vehicle=   92  Arrive=  965  Depart=  965  Int.Delay=     0  Tot.Delay=    0
Vehicle=   96  Arrive=  979  Depart= 1026  Int.Delay=     0  Tot.Delay=   47
Vehicle=   97  Arrive=  988  Depart= 1028  Int.Delay=     0  Tot.Delay=   40
Vehicle=   98  Arrive=  997  Depart= 1030  Int.Delay=     0  Tot.Delay=   33
Vehicle=   99  Arrive= 1005  Depart= 1032  Int.Delay=     0  Tot.Delay=   27
Vehicle=  100  Arrive= 1022  Depart= 1034  Int.Delay=     0  Tot.Delay=   12
Vehicle=  104  Arrive= 1064  Depart= 1101  Int.Delay=     0  Tot.Delay=   37
Vehicle=  105  Arrive= 1085  Depart= 1103  Int.Delay=     0  Tot.Delay=   18
Vehicle=  106  Arrive= 1111  Depart= 1111  Int.Delay=     0  Tot.Delay=    0
Vehicle=  107  Arrive= 1122  Depart= 1122  Int.Delay=     0  Tot.Delay=    0
Vehicle=  111  Arrive= 1136  Depart= 1176  Int.Delay=     0  Tot.Delay=   40
Vehicle=  112  Arrive= 1142  Depart= 1178  Int.Delay=     0  Tot.Delay=   36
Vehicle=  113  Arrive= 1199  Depart= 1199  Int.Delay=     0  Tot.Delay=    0
Vehicle=  117  Arrive= 1241  Depart= 1251  Int.Delay=     0  Tot.Delay=   10
Vehicle=  118  Arrive= 1260  Depart= 1260  Int.Delay=     0  Tot.Delay=    0
Vehicle=  119  Arrive= 1268  Depart= 1268  Int.Delay=     0  Tot.Delay=    0
Vehicle=  123  Arrive= 1312  Depart= 1326  Int.Delay=     0  Tot.Delay=   14
Vehicle=  124  Arrive= 1334  Depart= 1334  Int.Delay=     0  Tot.Delay=    0
Vehicle=  125  Arrive= 1338  Depart= 1338  Int.Delay=     0  Tot.Delay=    0
Vehicle=  126  Arrive= 1344  Depart= 1344  Int.Delay=     0  Tot.Delay=    0
```

```
Vehicle=  130  Arrive= 1354  Depart= 1401  Int.Delay=    0  Tot.Delay=  47
Vehicle=  131  Arrive= 1360  Depart= 1403  Int.Delay=    0  Tot.Delay=  43
Vehicle=  132  Arrive= 1393  Depart= 1405  Int.Delay=    0  Tot.Delay=  12
Vehicle=  133  Arrive= 1398  Depart= 1407  Int.Delay=    0  Tot.Delay=   9
Vehicle=  134  Arrive= 1413  Depart= 1413  Int.Delay=    0  Tot.Delay=   0
Vehicle=  135  Arrive= 1416  Depart= 1416  Int.Delay=    0  Tot.Delay=   0
Vehicle=  139  Arrive= 1433  Depart= 1476  Int.Delay=    0  Tot.Delay=  43
Vehicle=  140  Arrive= 1448  Depart= 1478  Int.Delay=    0  Tot.Delay=  30
Vehicle=  141  Arrive= 1452  Depart= 1480  Int.Delay=    0  Tot.Delay=  28
Vehicle=  142  Arrive= 1473  Depart= 1482  Int.Delay=    0  Tot.Delay=   9
Vehicle=  143  Arrive= 1476  Depart= 1484  Int.Delay=    0  Tot.Delay=   8
Vehicle=  147  Arrive= 1511  Depart= 1551  Int.Delay=    0  Tot.Delay=  40
Vehicle=  148  Arrive= 1541  Depart= 1553  Int.Delay=    0  Tot.Delay=  12
Vehicle=  149  Arrive= 1544  Depart= 1555  Int.Delay=    0  Tot.Delay=  11
Vehicle=  153  Arrive= 1599  Depart= 1626  Int.Delay=    0  Tot.Delay=  27
Vehicle=  154  Arrive= 1617  Depart= 1628  Int.Delay=    0  Tot.Delay=  11
Vehicle=  155  Arrive= 1640  Depart= 1640  Int.Delay=    0  Tot.Delay=   0
Vehicle=  156  Arrive= 1646  Depart= 1646  Int.Delay=    0  Tot.Delay=   0
Vehicle=  160  Arrive= 1657  Depart= 1701  Int.Delay=    0  Tot.Delay=  44
Vehicle=  161  Arrive= 1706  Depart= 1706  Int.Delay=    0  Tot.Delay=   0
Vehicle=  162  Arrive= 1712  Depart= 1712  Int.Delay=    0  Tot.Delay=   0
Vehicle=  166  Arrive= 1727  Depart= 1776  Int.Delay=    0  Tot.Delay=  49
Vehicle=  167  Arrive= 1733  Depart= 1778  Int.Delay=    0  Tot.Delay=  45
Vehicle=  168  Arrive= 1747  Depart= 1780  Int.Delay=    0  Tot.Delay=  33
Vehicle=  169  Arrive= 1751  Depart= 1782  Int.Delay=    0  Tot.Delay=  31
Vehicle=  170  Arrive= 1768  Depart= 1784  Int.Delay=    0  Tot.Delay=  16
Vehicle=  171  Arrive= 1779  Depart= 1786  Int.Delay=    0  Tot.Delay=   7
Vehicle=  175  Arrive= 1825  Depart= 1851  Int.Delay=    0  Tot.Delay=  26
Vehicle=  176  Arrive= 1829  Depart= 1853  Int.Delay=    0  Tot.Delay=  24
Vehicle=  177  Arrive= 1849  Depart= 1855  Int.Delay=    0  Tot.Delay=   6
Vehicle=  181  Arrive= 1896  Depart= 1926  Int.Delay=    0  Tot.Delay=  30
Vehicle=  182  Arrive= 1904  Depart= 1928  Int.Delay=    0  Tot.Delay=  24
Vehicle=  183  Arrive= 1929  Depart= 1930  Int.Delay=    0  Tot.Delay=   1
Vehicle=  184  Arrive= 1933  Depart= 1933  Int.Delay=    0  Tot.Delay=   0
Vehicle=  185  Arrive= 1939  Depart= 1939  Int.Delay=    0  Tot.Delay=   0
Vehicle=  186  Arrive= 1947  Depart= 1947  Int.Delay=    0  Tot.Delay=   0
Vehicle=  190  Arrive= 1960  Depart= 2001  Int.Delay=    0  Tot.Delay=  41
Vehicle=  191  Arrive= 2003  Depart= 2003  Int.Delay=    0  Tot.Delay=   0
Vehicle=  192  Arrive= 2016  Depart= 2016  Int.Delay=    0  Tot.Delay=   0
Vehicle=  196  Arrive= 2054  Depart= 2076  Int.Delay=    0  Tot.Delay=  22
Vehicle=  197  Arrive= 2066  Depart= 2078  Int.Delay=    0  Tot.Delay=  12
Vehicle=  198  Arrive= 2075  Depart= 2080  Int.Delay=    0  Tot.Delay=   5
Vehicle=  202  Arrive= 2118  Depart= 2151  Int.Delay=    0  Tot.Delay=  33
Vehicle=  203  Arrive= 2157  Depart= 2157  Int.Delay=    0  Tot.Delay=   0
Vehicle=  207  Arrive= 2216  Depart= 2226  Int.Delay=    0  Tot.Delay=  10
Vehicle=  211  Arrive= 2284  Depart= 2301  Int.Delay=    0  Tot.Delay=  17
Vehicle=  212  Arrive= 2286  Depart= 2303  Int.Delay=    0  Tot.Delay=  17
Vehicle=  213  Arrive= 2320  Depart= 2320  Int.Delay=    0  Tot.Delay=   0
Vehicle=  214  Arrive= 2323  Depart= 2323  Int.Delay=    0  Tot.Delay=   0
Vehicle=  218  Arrive= 2329  Depart= 2376  Int.Delay=    0  Tot.Delay=  47
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Vehicle=  219  Arrive= 2333  Depart= 2378  Int.Delay=    0  Tot.Delay=   45
Vehicle=  220  Arrive= 2349  Depart= 2380  Int.Delay=    0  Tot.Delay=   31
Vehicle=  221  Arrive= 2354  Depart= 2382  Int.Delay=    0  Tot.Delay=   28
Vehicle=  222  Arrive= 2395  Depart= 2395  Int.Delay=    0  Tot.Delay=    0
Vehicle=  223  Arrive= 2399  Depart= 2399  Int.Delay=    0  Tot.Delay=    0
Vehicle=  227  Arrive= 2432  Depart= 2451  Int.Delay=    0  Tot.Delay=   19
Vehicle=  228  Arrive= 2439  Depart= 2453  Int.Delay=    0  Tot.Delay=   14
Vehicle=  229  Arrive= 2444  Depart= 2455  Int.Delay=    0  Tot.Delay=   11
Vehicle=  233  Arrive= 2484  Depart= 2526  Int.Delay=    0  Tot.Delay=   42
Vehicle=  234  Arrive= 2535  Depart= 2535  Int.Delay=    0  Tot.Delay=    0
Vehicle=  235  Arrive= 2542  Depart= 2542  Int.Delay=    0  Tot.Delay=    0
Vehicle=  239  Arrive= 2552  Depart= 2601  Int.Delay=    0  Tot.Delay=   49
Vehicle=  240  Arrive= 2566  Depart= 2603  Int.Delay=    0  Tot.Delay=   37
Vehicle=  244  Arrive= 2627  Depart= 2676  Int.Delay=    0  Tot.Delay=   49
Vehicle=  245  Arrive= 2684  Depart= 2684  Int.Delay=    0  Tot.Delay=    0
Vehicle=  246  Arrive= 2688  Depart= 2688  Int.Delay=    0  Tot.Delay=    0
Vehicle=  250  Arrive= 2709  Depart= 2751  Int.Delay=    0  Tot.Delay=   42
Vehicle=  251  Arrive= 2738  Depart= 2753  Int.Delay=    0  Tot.Delay=   15
Vehicle=  252  Arrive= 2751  Depart= 2755  Int.Delay=    0  Tot.Delay=    4
Vehicle=  253  Arrive= 2767  Depart= 2767  Int.Delay=    0  Tot.Delay=    0
Vehicle=  257  Arrive= 2796  Depart= 2826  Int.Delay=    0  Tot.Delay=   30
Vehicle=  258  Arrive= 2821  Depart= 2828  Int.Delay=    0  Tot.Delay=    7
Vehicle=  259  Arrive= 2824  Depart= 2830  Int.Delay=    0  Tot.Delay=    6
Vehicle=  260  Arrive= 2847  Depart= 2847  Int.Delay=    0  Tot.Delay=    0
Vehicle=  264  Arrive= 2877  Depart= 2901  Int.Delay=    0  Tot.Delay=   24
Vehicle=  265  Arrive= 2879  Depart= 2903  Int.Delay=    0  Tot.Delay=   24
Vehicle=  266  Arrive= 2899  Depart= 2905  Int.Delay=    0  Tot.Delay=    6
Vehicle=  267  Arrive= 2[illegible]2  Depart= 2907  Int.Delay=    0  Tot.Delay=    5
Vehicle=  268  Arrive= 2906  Depart= 2909  Int.Delay=    0  Tot.Delay=    3
Vehicle=  272  Arrive= 2926  Depart= 2976  Int.Delay=    0  Tot.Delay=   50
Vehicle=  273  Arrive= 2937  Depart= 2978  Int.Delay=    0  Tot.Delay=   41
Vehicle=  274  Arrive= 2965  Depart= 2980  Int.Delay=    0  Tot.Delay=   15
Vehicle=  275  Arrive= 2968  Depart= 2982  Int.Delay=    0  Tot.Delay=   14
Vehicle=  276  Arrive= 2987  Depart= 2987  Int.Delay=    0  Tot.Delay=    0
Vehicle=  277  Arrive= 2990  Depart= 2990  Int.Delay=    0  Tot.Delay=    0
Vehicle=  278  Arrive= 2992  Depart= 2992  Int.Delay=    0  Tot.Delay=    0
Vehicle=  279  Arrive= 2997  Depart= 2997  Int.Delay=    0  Tot.Delay=    0
Vehicle=  283  Arrive= 3035  Depart= 3051  Int.Delay=    0  Tot.Delay=   16
Vehicle=  284  Arrive= 3057  Depart= 3057  Int.Delay=    0  Tot.Delay=    0
Vehicle=  285  Arrive= 3070  Depart= 3070  Int.Delay=    0  Tot.Delay=    0
Vehicle=  289  Arrive= 3085  Depart= 3126  Int.Delay=    0  Tot.Delay=   41
Vehicle=  290  Arrive= 3095  Depart= 3128  Int.Delay=    0  Tot.Delay=   33
Vehicle=  291  Arrive= 3101  Depart= 3130  Int.Delay=    0  Tot.Delay=   29
Vehicle=  292  Arrive= 3117  Depart= 3132  Int.Delay=    0  Tot.Delay=   15
Vehicle=  293  Arrive= 3127  Depart= 3134  Int.Delay=    0  Tot.Delay=    7
Vehicle=  294  Arrive= 3142  Depart= 3142  Int.Delay=    0  Tot.Delay=    0
Vehicle=  298  Arrive= 3150  Depart= 3201  Int.Delay=    0  Tot.Delay=   51
Vehicle=  299  Arrive= 3192  Depart= 3203  Int.Delay=    0  Tot.Delay=   11
Vehicle=  300  Arrive= 3212  Depart= 3212  Int.Delay=    0  Tot.Delay=    0
Vehicle=  304  Arrive= 3259  Depart= 3276  Int.Delay=    0  Tot.Delay=   17
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Vehicle=  305  Arrive= 3274  Depart= 3278  Int.Delay=    0  Tot.Delay=   4
Vehicle=  306  Arrive= 3285  Depart= 3285  Int.Delay=    0  Tot.Delay=   0
Vehicle=  307  Arrive= 3296  Depart= 3296  Int.Delay=    0  Tot.Delay=   0
Vehicle=  311  Arrive= 3305  Depart= 3351  Int.Delay=    0  Tot.Delay=  46
Vehicle=  312  Arrive= 3323  Depart= 3353  Int.Delay=    0  Tot.Delay=  30
Vehicle=  313  Arrive= 3359  Depart= 3359  Int.Delay=    0  Tot.Delay=   0
Vehicle=  317  Arrive= 3379  Depart= 3426  Int.Delay=    0  Tot.Delay=  47
Vehicle=  318  Arrive= 3390  Depart= 3428  Int.Delay=    0  Tot.Delay=  38
Vehicle=  319  Arrive= 3402  Depart= 3430  Int.Delay=    0  Tot.Delay=  28
Vehicle=  320  Arrive= 3446  Depart= 3446  Int.Delay=    0  Tot.Delay=   0
Vehicle=  324  Arrive= 3475  Depart= 3501  Int.Delay=    0  Tot.Delay=  26
Vehicle=  325  Arrive= 3512  Depart= 3512  Int.Delay=    0  Tot.Delay=   0
Vehicle=  329  Arrive= 3583  Depart= 3583  Int.Delay=    0  Tot.Delay=   0
 Side Street Traffic     Vehicle=    1  Disch=    1
 Side Street Traffic     Vehicle=    2  Disch=   20
 Side Street Traffic     Vehicle=    3  Disch=   39
 Side Street Traffic     Vehicle=    8  Disch=   75
 Side Street Traffic     Vehicle=    9  Disch=   94
 Side Street Traffic     Vehicle=   10  Disch=  113
 Side Street Traffic     Vehicle=   14  Disch=  150
 Side Street Traffic     Vehicle=   15  Disch=  169
 Side Street Traffic     Vehicle=   16  Disch=  188
 Side Street Traffic     Vehicle=   23  Disch=  225
 Side Street Traffic     Vehicle=   24  Disch=  244
 Side Street Traffic     Vehicle=   25  Disch=  263
 Side Street Traffic     Vehicle=   29  Disch=  300
 Side Street Traffic     Vehicle=   30  Disch=  319
 Side Street Traffic     Vehicle=   31  Disch=  338
 Side Street Traffic     Vehicle=   39  Disch=  375
 Side Street Traffic     Vehicle=   40  Disch=  394
 Side Street Traffic     Vehicle=   41  Disch=  413
 Side Street Traffic     Vehicle=   46  Disch=  450
 Side Street Traffic     Vehicle=   47  Disch=  469
 Side Street Traffic     Vehicle=   48  Disch=  488
 Side Street Traffic     Vehicle=   50  Disch=  525
 Side Street Traffic     Vehicle=   51  Disch=  544
 Side Street Traffic     Vehicle=   52  Disch=  563
 Side Street Traffic     Vehicle=   57  Disch=  600
 Side Street Traffic     Vehicle=   58  Disch=  619
 Side Street Traffic     Vehicle=   59  Disch=  638
 Side Street Traffic     Vehicle=   67  Disch=  675
 Side Street Traffic     Vehicle=   68  Disch=  694
 Side Street Traffic     Vehicle=   69  Disch=  713
 Side Street Traffic     Vehicle=   75  Disch=  750
 Side Street Traffic     Vehicle=   76  Disch=  769
 Side Street Traffic     Vehicle=   77  Disch=  788
 Side Street Traffic     Vehicle=   81  Disch=  825
 Side Street Traffic     Vehicle=   82  Disch=  844
 Side Street Traffic     Vehicle=   83  Disch=  863
 Side Street Traffic     Vehicle=   85  Disch=  900
Side Street Traffic     Vehicle=   86  Disch=  919
Side Street Traffic     Vehicle=   87  Disch=  938
Side Street Traffic     Vehicle=   93  Disch=  975
Side Street Traffic     Vehicle=   94  Disch=  994
Side Street Traffic     Vehicle=   95  Disch= 1013
Side Street Traffic     Vehicle=  101  Disch= 1050
Side Street Traffic     Vehicle=  102  Disch= 1069
Side Street Traffic     Vehicle=  103  Disch= 1088
Side Street Traffic     Vehicle=  108  Disch= 1125
Side Street Traffic     Vehicle=  109  Disch= 1144
Side Street Traffic     Vehicle=  110  Disch= 1163
Side Street Traffic     Vehicle=  114  Disch= 1200
Side Street Traffic     Vehicle=  115  Disch= 1219
Side Street Traffic     Vehicle=  116  Disch= 1238
Side Street Traffic     Vehicle=  120  Disch= 1275
Side Street Traffic     Vehicle=  121  Disch= 1294
Side Street Traffic     Vehicle=  122  Disch= 1313
Side Street Traffic     Vehicle=  127  Disch= 1350
Side Street Traffic     Vehicle=  128  Disch= 1369
Side Street Traffic     Vehicle=  129  Disch= 1388
Side Street Traffic     Vehicle=  136  Disch= 1425
Side Street Traffic     Vehicle=  137  Disch= 1444
Side Street Traffic     Vehicle=  138  Disch= 1463
Side Street Traffic     Vehicle=  144  Disch= 1500
Side Street Traffic     Vehicle=  145  Disch= 1519
Side Street Traffic     Vehicle=  146  Disch= 1538
Side Street Traffic     Vehicle=  150  Disch= 1575
Side Street Traffic     Vehicle=  151  Disch= 1594
Side Street Traffic     Vehicle=  152  Disch= 1613
Side Street Traffic     Vehicle=  157  Disch= 1650
Side Street Traffic     Vehicle=  158  Disch= 1669
Side Street Traffic     Vehicle=  159  Disch= 1688
Side Street Traffic     Vehicle=  163  Disch= 1725
Side Street Traffic     Vehicle=  164  Disch= 1744
Side Street Traffic     Vehicle=  165  Disch= 1763
Side Street Traffic     Vehicle=  172  Disch= 1800
Side Street Traffic     Vehicle=  173  Disch= 1819
Side Street Traffic     Vehicle=  174  Disch= 1838
Side Street Traffic     Vehicle=  178  Disch= 1875
Side Street Traffic     Vehicle=  179  Disch= 1894
Side Street Traffic     Vehicle=  180  Disch= 1913
Side Street Traffic     Vehicle=  187  Disch= 1950
Side Street Traffic     Vehicle=  188  Disch= 1969
Side Street Traffic     Vehicle=  189  Disch= 1988
Side Street Traffic     Vehicle=  193  Disch= 2025
Side Street Traffic     Vehicle=  194  Disch= 2044
Side Street Traffic     Vehicle=  195  Disch= 2063
Side Street Traffic     Vehicle=  199  Disch= 2100
Side Street Traffic     Vehicle=  200  Disch= 2119
Side Street Traffic     Vehicle=  201  Disch= 2138
Side Street Traffic     Vehicle=  204  Disch= 2175
Side Street Traffic     Vehicle=  205  Disch= 2194
Side Street Traffic     Vehicle=  206  Disch= 2213
Side Street Traffic     Vehicle=  208  Disch= 2250
Side Street Traffic     Vehicle=  209  Disch= 2269
Side Street Traffic     Vehicle=  210  Disch= 2288
Side Street Traffic     Vehicle=  215  Disch= 2325
Side Street Traffic     Vehicle=  216  Disch= 2344
Side Street Traffic     Vehicle=  217  Disch= 2363
Side Street Traffic     Vehicle=  224  Disch= 2400
Side Street Traffic     Vehicle=  225  Disch= 2419
Side Street Traffic     Vehicle=  226  Disch= 2438
Side Street Traffic     Vehicle=  230  Disch= 2475
Side Street Traffic     Vehicle=  231  Disch= 2494
Side Street Traffic     Vehicle=  232  Disch= 2513
Side Street Traffic     Vehicle=  236  Disch= 2550
Side Street Traffic     Vehicle=  237  Disch= 2569
Side Street Traffic     Vehicle=  238  Disch= 2588
Side Street Traffic     Vehicle=  241  Disch= 2625
Side Street Traffic     Vehicle=  242  Disch= 2644
Side Street Traffic     Vehicle=  243  Disch= 2663
Side Street Traffic     Vehicle=  247  Disch= 2700
Side Street Traffic     Vehicle=  248  Disch= 2719
Side Street Traffic     Vehicle=  249  Disch= 2738
Side Street Traffic     Vehicle=  254  Disch= 2775
Side Street Traffic     Vehicle=  255  Disch= 2794
Side Street Traffic     Vehicle=  256  Disch= 2813
Side Street Traffic     Vehicle=  261  Disch= 2850
Side Street Traffic     Vehicle=  262  Disch= 2869
Side Street Traffic     Vehicle=  263  Disch= 2888
Side Street Traffic     Vehicle=  269  Disch= 2925
Side Street Traffic     Vehicle=  270  Disch= 2944
Side Street Traffic     Vehicle=  271  Disch= 2963
Side Street Traffic     Vehicle=  280  Disch= 3000
Side Street Traffic     Vehicle=  281  Disch= 3019
Side Street Traffic     Vehicle=  282  Disch= 3038
Side Street Traffic     Vehicle=  286  Disch= 3075
Side Street Traffic     Vehicle=  287  Disch= 3094
Side Street Traffic     Vehicle=  288  Disch= 3113
Side Street Traffic     Vehicle=  295  Disch= 3150
Side Street Traffic     Vehicle=  296  Disch= 3169
Side Street Traffic     Vehicle=  297  Disch= 3188
Side Street Traffic     Vehicle=  301  Disch= 3225
Side Street Traffic     Vehicle=  302  Disch= 3244
Side Street Traffic     Vehicle=  303  Disch= 3263
Side Street Traffic     Vehicle=  308  Disch= 3300
Side Street Traffic     Vehicle=  309  Disch= 3319
Side Street Traffic     Vehicle=  310  Disch= 3338
Side Street Traffic     Vehicle=  314  Disch= 3375
Side Street Traffic     Vehicle=  315  Disch= 3394
Side Street Traffic     Vehicle=  316  Disch= 3413
Side Street Traffic     Vehicle=  321  Disch= 3450
Side Street Traffic     Vehicle=  322  Disch= 3469
Side Street Traffic     Vehicle=  323  Disch= 3488
Side Street Traffic     Vehicle=  326  Disch= 3525
Side Street Traffic     Vehicle=  327  Disch= 3544
Side Street Traffic     Vehicle=  328  Disch= 3563
Average Intersection Vehicle Delay =  17.00
Average Total Vehicle Delay        =  17.00
Ped=    1  Arrive=   55  Depart=   55  Delay=    0
Ped=    2  Arrive=   74  Depart=  120  Delay=   46
Ped=    3  Arrive=   84  Depart=  120  Delay=   36
Ped=    4  Arrive=  112  Depart=  120  Delay=    8
Ped=    5  Arrive=  117  Depart=  120  Delay=    3
Ped=    6  Arrive=  143  Depart=  185  Delay=   42
Ped=    7  Arrive=  152  Depart=  185  Delay=   33
Ped=    8  Arrive=  185  Depart=  185  Delay=    0
Ped=    9  Arrive=  225  Depart=  250  Delay=   25
Ped=   10  Arrive=  285  Depart=  315  Delay=   30
Ped=   11  Arrive=  325  Depart=  380  Delay=   55
Ped=   12  Arrive=  335  Depart=  380  Delay=   45
Ped=   13  Arrive=  353  Depart=  380  Delay=   27
Ped=   14  Arrive=  364  Depart=  380  Delay=   16
Ped=   15  Arrive=  369  Depart=  380  Delay=   11
Ped=   16  Arrive=  371  Depart=  380  Delay=    9
Ped=   17  Arrive=  405  Depart=  445  Delay=   40
Ped=   18  Arrive=  420  Depart=  445  Delay=   25
Ped=   19  Arrive=  438  Depart=  445  Delay=    7
Ped=   20  Arrive=  447  Depart=  447  Delay=    0
Ped=   21  Arrive=  462  Depart=  510  Delay=   48
Ped=   22  Arrive=  583  Depart=  583  Delay=    0
Ped=   23  Arrive=  633  Depart=  648  Delay=   15
Ped=   24  Arrive=  641  Depart=  648  Delay=    7
Ped=   25  Arrive=  646  Depart=  648  Delay=    2
Ped=   26  Arrive=  685  Depart=  713  Delay=   28
Ped=   27  Arrive=  725  Depart=  778  Delay=   53
Ped=   28  Arrive=  895  Depart=  895  Delay=    0
Ped=   29  Arrive=  931  Depart=  960  Delay=   29
Ped=   30  Arrive=  935  Depart=  960  Delay=   25
Ped=   31  Arrive=  950  Depart=  960  Delay=   10
Ped=   32  Arrive= 1026  Depart= 1026  Delay=    0
Ped=   33  Arrive= 1047  Depart= 1091  Delay=   44
Ped=   34  Arrive= 1057  Depart= 1091  Delay=   34
Ped=   35  Arrive= 1066  Depart= 1091  Delay=   25
Ped=   36  Arrive= 1150  Depart= 1156  Delay=    6
Ped=   37  Arrive= 1155  Depart= 1156  Delay=    1
Ped=   38  Arrive= 1166  Depart= 1221  Delay=   55
Ped=   39  Arrive= 1176  Depart= 1221  Delay=   45
Ped=   40  Arrive= 1184  Depart= 1221  Delay=   37
Ped=   41  Arrive= 1195  Depart= 1221  Delay=   26
```

```
Ped=  42  Arrive= 1240  Depart= 1286  Delay=  46
Ped=  43  Arrive= 1250  Depart= 1286  Delay=  36
Ped=  44  Arrive= 1264  Depart= 1286  Delay=  22
Ped=  45  Arrive= 1288  Depart= 1288  Delay=   0
Ped=  46  Arrive= 1292  Depart= 1292  Delay=   0
Ped=  47  Arrive= 1304  Depart= 1351  Delay=  47
Ped=  48  Arrive= 1309  Depart= 1351  Delay=  42
Ped=  49  Arrive= 1311  Depart= 1351  Delay=  40
Ped=  50  Arrive= 1317  Depart= 1351  Delay=  34
Ped=  51  Arrive= 1386  Depart= 1416  Delay=  30
Ped=  52  Arrive= 1392  Depart= 1416  Delay=  24
Ped=  53  Arrive= 1424  Depart= 1424  Delay=   0
Ped=  54  Arrive= 1453  Depart= 1481  Delay=  28
Ped=  55  Arrive= 1512  Depart= 1546  Delay=  34
Ped=  56  Arrive= 1556  Depart= 1611  Delay=  55
Ped=  57  Arrive= 1627  Depart= 1676  Delay=  49
Ped=  58  Arrive= 1647  Depart= 1676  Delay=  29
Ped=  59  Arrive= 1688  Depart= 1741  Delay=  53
Ped=  60  Arrive= 1764  Depart= 1806  Delay=  42
Ped=  61  Arrive= 1790  Depart= 1806  Delay=  16
Ped=  62  Arrive= 1795  Depart= 1806  Delay=  11
Ped=  63  Arrive= 1811  Depart= 1811  Delay=   0
Ped=  64  Arrive= 1824  Depart= 1871  Delay=  47
Ped=  65  Arrive= 1829  Depart= 1871  Delay=  42
Ped=  66  Arrive= 1844  Depart= 1871  Delay=  27
Ped=  67  Arrive= 1885  Depart= 1936  Delay=  51
Ped=  68  Arrive= 1893  Depart= 1936  Delay=  43
Ped=  69  Arrive= 1899  Depart= 1936  Delay=  37
Ped=  70  Arrive= 1903  Depart= 1936  Delay=  33
Ped=  71  Arrive= 1911  Depart= 1936  Delay=  25
Ped=  72  Arrive= 1913  Depart= 1936  Delay=  23
Ped=  73  Arrive= 1924  Depart= 1936  Delay=  12
Ped=  74  Arrive= 1947  Depart= 2001  Delay=  54
Ped=  75  Arrive= 1960  Depart= 2001  Delay=  41
Ped=  76  Arrive= 1980  Depart= 2001  Delay=  21
Ped=  77  Arrive= 1980  Depart= 2001  Delay=  21
Ped=  78  Arrive= 1988  Depart= 2001  Delay=  13
Ped=  79  Arrive= 2003  Depart= 2003  Delay=   0
Ped=  80  Arrive= 2012  Depart= 2066  Delay=  54
Ped=  81  Arrive= 2015  Depart= 2066  Delay=  51
Ped=  82  Arrive= 2032  Depart= 2066  Delay=  34
Ped=  83  Arrive= 2065  Depart= 2066  Delay=   1
Ped=  84  Arrive= 2095  Depart= 2131  Delay=  36
Ped=  85  Arrive= 2099  Depart= 2131  Delay=  32
Ped=  86  Arrive= 2280  Depart= 2280  Delay=   0
Ped=  87  Arrive= 2343  Depart= 2345  Delay=   2
Ped=  88  Arrive= 2347  Depart= 2347  Delay=   0
Ped=  89  Arrive= 2467  Depart= 2467  Delay=   0
Ped=  90  Arrive= 2489  Depart= 2532  Delay=  43
Ped=  91  Arrive= 2502  Depart= 2532  Delay=  30
```

```
Ped=   92  Arrive= 2513  Depart= 2532  Delay=   19
Ped=   93  Arrive= 2552  Depart= 2597  Delay=   45
Ped=   94  Arrive= 2559  Depart= 2597  Delay=   38
Ped=   95  Arrive= 2568  Depart= 2597  Delay=   29
Ped=   96  Arrive= 2574  Depart= 2597  Delay=   23
Ped=   97  Arrive= 2614  Depart= 2662  Delay=   48
Ped=   98  Arrive= 2632  Depart= 2662  Delay=   30
Ped=   99  Arrive= 2638  Depart= 2662  Delay=   24
Ped=  100  Arrive= 2644  Depart= 2662  Delay=   18
Ped=  101  Arrive= 2658  Depart= 2662  Delay=    4
Ped=  102  Arrive= 2663  Depart= 2663  Delay=    0
Ped=  103  Arrive= 2670  Depart= 2670  Delay=    0
Ped=  104  Arrive= 2691  Depart= 2727  Delay=   36
Ped=  105  Arrive= 2717  Depart= 2727  Delay=   10
Ped=  106  Arrive= 2752  Depart= 2792  Delay=   40
Ped=  107  Arrive= 2764  Depart= 2792  Delay=   28
Ped=  108  Arrive= 2789  Depart= 2792  Delay=    3
Ped=  109  Arrive= 2789  Depart= 2792  Delay=    3
Ped=  110  Arrive= 2810  Depart= 2857  Delay=   47
Ped=  111  Arrive= 2843  Depart= 2857  Delay=   14
Ped=  112  Arrive= 2914  Depart= 2922  Delay=    8
Ped=  113  Arrive= 2915  Depart= 2922  Delay=    7
Ped=  114  Arrive= 2924  Depart= 2924  Delay=    0
Ped=  115  Arrive= 2956  Depart= 2987  Delay=   31
Ped=  116  Arrive= 2972  Depart= 2987  Delay=   15
Ped=  117  Arrive= 2999  Depart= 3052  Delay=   53
Ped=  118  Arrive= 3001  Depart= 3052  Delay=   51
Ped=  119  Arrive= 3078  Depart= 3117  Delay=   39
Ped=  120  Arrive= 3087  Depart= 3117  Delay=   30
Ped=  121  Arrive= 3104  Depart= 3117  Delay=   13
Ped=  122  Arrive= 3149  Depart= 3182  Delay=   33
Ped=  123  Arrive= 3165  Depart= 3182  Delay=   17
Ped=  124  Arrive= 3175  Depart= 3182  Delay=    7
Ped=  125  Arrive= 3180  Depart= 3182  Delay=    2
Ped=  126  Arrive= 3181  Depart= 3182  Delay=    1
Ped=  127  Arrive= 3187  Depart= 3187  Delay=    0
Ped=  128  Arrive= 3204  Depart= 3247  Delay=   43
Ped=  129  Arrive= 3253  Depart= 3253  Delay=    0
Ped=  130  Arrive= 3316  Depart= 3316  Delay=    0
Ped=  131  Arrive= 3367  Depart= 3381  Delay=   14
Ped=  132  Arrive= 3401  Depart= 3446  Delay=   45
Ped=  133  Arrive= 3415  Depart= 3446  Delay=   31
Ped=  134  Arrive= 3428  Depart= 3446  Delay=   18
Ped=  135  Arrive= 3435  Depart= 3446  Delay=   11
Ped=  136  Arrive= 3446  Depart= 3446  Delay=    0
Ped=  137  Arrive= 3469  Depart= 3511  Delay=   42
Ped=  138  Arrive= 3498  Depart= 3511  Delay=   13
Ped=  139  Arrive= 3521  Depart= 3576  Delay=   55
Veh Red at Time =      55       1
Veh Red at Time =     120       2
Veh Red at Time =    185     3
Veh Red at Time =    250     4
Veh Red at Time =    315     5
Veh Red at Time =    380     6
Veh Red at Time =    445     7
Veh Red at Time =    510     8
Veh Red at Time =    583     9
Veh Red at Time =    648    10
Veh Red at Time =    713    11
Veh Red at Time =    778    12
Veh Red at Time =    895    13
Veh Red at Time =    960    14
Veh Red at Time =   1026    15
Veh Red at Time =   1091    16
Veh Red at Time =   1156    17
Veh Red at Time =   1221    18
Veh Red at Time =   1286    19
Veh Red at Time =   1351    20
Veh Red at Time =   1416    21
Veh Red at Time =   1481    22
Veh Red at Time =   1546    23
Veh Red at Time =   1611    24
Veh Red at Time =   1676    25
Veh Red at Time =   1741    26
Veh Red at Time =   1806    27
Veh Red at Time =   1871    28
Veh Red at Time =   1936    29
Veh Red at Time =   2001    30
Veh Red at Time =   2066    31
Veh Red at Time =   2131    32
Veh Red at Time =   2280    33
Veh Red at Time =   2345    34
Veh Red at Time =   2467    35
Veh Red at Time =   2532    36
Veh Red at Time =   2597    37
Veh Red at Time =   2662    38
Veh Red at Time =   2727    39
Veh Red at Time =   2792    40
Veh Red at Time =   2857    41
Veh Red at Time =   2922    42
Veh Red at Time =   2987    43
Veh Red at Time =   3052    44
Veh Red at Time =   3117    45
Veh Red at Time =   3182    46
Veh Red at Time =   3247    47
Veh Red at Time =   3316    48
Veh Red at Time =   3381    49
Veh Red at Time =   3446    50
Veh Red at Time =   3511    51
Veh Red at Time =   3576    52
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  Veh Red at Time =      0     53
  Veh Red at Time =      0     54
  Average Ped. Delay =  24.26

Vehicle=    1  Arrive=   11  Depart=   11  Int.Delay=    0  Tot.Delay=    0
Vehicle=    2  Arrive=   30  Depart=   30  Int.Delay=    0  Tot.Delay=    0
Vehicle=    3  Arrive=   49  Depart=   49  Int.Delay=    0  Tot.Delay=    0
Vehicle=    4  Arrive=   61  Depart=   80  Int.Delay=   19  Tot.Delay=   58
Vehicle=    5  Arrive=   63  Depart=   82  Int.Delay=   19  Tot.Delay=   37
Vehicle=    6  Arrive=   65  Depart=   84  Int.Delay=   19  Tot.Delay=   35
Vehicle=    7  Arrive=   79  Depart=   86  Int.Delay=    7  Tot.Delay=    7
Vehicle=    8  Arrive=   85  Depart=   88  Int.Delay=    3  Tot.Delay=    3
Vehicle=    9  Arrive=  104  Depart=  104  Int.Delay=    0  Tot.Delay=    0
Vehicle=   10  Arrive=  123  Depart=  145  Int.Delay=   22  Tot.Delay=   22
Vehicle=   11  Arrive=  136  Depart=  147  Int.Delay=   11  Tot.Delay=   42
Vehicle=   12  Arrive=  138  Depart=  149  Int.Delay=   11  Tot.Delay=   40
Vehicle=   13  Arrive=  142  Depart=  151  Int.Delay=    9  Tot.Delay=    9
Vehicle=   14  Arrive=  160  Depart=  160  Int.Delay=    0  Tot.Delay=    0
Vehicle=   15  Arrive=  179  Depart=  179  Int.Delay=    0  Tot.Delay=    0
Vehicle=   16  Arrive=  198  Depart=  210  Int.Delay=   12  Tot.Delay=   12
Vehicle=   17  Arrive=  211  Depart=  212  Int.Delay=    1  Tot.Delay=   51
Vehicle=   18  Arrive=  213  Depart=  214  Int.Delay=    1  Tot.Delay=   30
Vehicle=   19  Arrive=  215  Depart=  216  Int.Delay=    1  Tot.Delay=   26
Vehicle=   20  Arrive=  217  Depart=  218  Int.Delay=    1  Tot.Delay=   16
Vehicle=   21  Arrive=  219  Depart=  220  Int.Delay=    1  Tot.Delay=   11
Vehicle=   22  Arrive=  231  Depart=  231  Int.Delay=    0  Tot.Delay=    0
Vehicle=   23  Arrive=  235  Depart=  235  Int.Delay=    0  Tot.Delay=    0
Vehicle=   24  Arrive=  254  Depart=  275  Int.Delay=   21  Tot.Delay=   21
Vehicle=   25  Arrive=  273  Depart=  277  Int.Delay=    4  Tot.Delay=    4
Vehicle=   26  Arrive=  286  Depart=  286  Int.Delay=    0  Tot.Delay=   14
Vehicle=   27  Arrive=  288  Depart=  288  Int.Delay=    0  Tot.Delay=    4
Vehicle=   28  Arrive=  303  Depart=  303  Int.Delay=    0  Tot.Delay=    0
Vehicle=   29  Arrive=  310  Depart=  310  Int.Delay=    0  Tot.Delay=    0
Vehicle=   30  Arrive=  329  Depart=  340  Int.Delay=   11  Tot.Delay=   11
Vehicle=   31  Arrive=  348  Depart=  348  Int.Delay=    0  Tot.Delay=    0
Vehicle=   32  Arrive=  361  Depart=  361  Int.Delay=    0  Tot.Delay=   45
Vehicle=   33  Arrive=  363  Depart=  363  Int.Delay=    0  Tot.Delay=   44
Vehicle=   34  Arrive=  365  Depart=  365  Int.Delay=    0  Tot.Delay=   25
Vehicle=   35  Arrive=  367  Depart=  367  Int.Delay=    0  Tot.Delay=   25
Vehicle=   36  Arrive=  369  Depart=  369  Int.Delay=    0  Tot.Delay=   17
Vehicle=   37  Arrive=  371  Depart=  371  Int.Delay=    0  Tot.Delay=   14
Vehicle=   38  Arrive=  373  Depart=  373  Int.Delay=    0  Tot.Delay=    7
Vehicle=   39  Arrive=  385  Depart=  405  Int.Delay=   20  Tot.Delay=   20
Vehicle=   40  Arrive=  404  Depart=  407  Int.Delay=    3  Tot.Delay=    3
Vehicle=   41  Arrive=  423  Depart=  423  Int.Delay=    0  Tot.Delay=    0
Vehicle=   42  Arrive=  436  Depart=  436  Int.Delay=    0  Tot.Delay=   38
Vehicle=   43  Arrive=  438  Depart=  438  Int.Delay=    0  Tot.Delay=   33
Vehicle=   44  Arrive=  440  Depart=  440  Int.Delay=    0  Tot.Delay=    3
Vehicle=   45  Arrive=  458  Depart=  470  Int.Delay=   12  Tot.Delay=   12
Vehicle=   46  Arrive=  460  Depart=  472  Int.Delay=   12  Tot.Delay=   12
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Vehicle=  47  Arrive=  479  Depart=  479  Int.Delay=   0  Tot.Delay=   0
Vehicle=  48  Arrive=  498  Depart=  498  Int.Delay=   0  Tot.Delay=   0
Vehicle=  49  Arrive=  511  Depart=  535  Int.Delay=  24  Tot.Delay=  43
Vehicle=  50  Arrive=  535  Depart=  537  Int.Delay=   2  Tot.Delay=   2
Vehicle=  51  Arrive=  554  Depart=  554  Int.Delay=   0  Tot.Delay=   0
Vehicle=  52  Arrive=  573  Depart=  573  Int.Delay=   0  Tot.Delay=   0
Vehicle=  53  Arrive=  586  Depart=  608  Int.Delay=  22  Tot.Delay=  70
Vehicle=  54  Arrive=  588  Depart=  610  Int.Delay=  22  Tot.Delay=  46
Vehicle=  55  Arrive=  590  Depart=  612  Int.Delay=  22  Tot.Delay=  44
Vehicle=  56  Arrive=  592  Depart=  614  Int.Delay=  22  Tot.Delay=  22
Vehicle=  57  Arrive=  610  Depart=  616  Int.Delay=   6  Tot.Delay=   6
Vehicle=  58  Arrive=  629  Depart=  629  Int.Delay=   0  Tot.Delay=   0
Vehicle=  59  Arrive=  648  Depart=  673  Int.Delay=  25  Tot.Delay=  25
Vehicle=  60  Arrive=  661  Depart=  675  Int.Delay=  14  Tot.Delay=  43
Vehicle=  61  Arrive=  663  Depart=  677  Int.Delay=  14  Tot.Delay=  37
Vehicle=  62  Arrive=  665  Depart=  679  Int.Delay=  14  Tot.Delay=  37
Vehicle=  63  Arrive=  667  Depart=  681  Int.Delay=  14  Tot.Delay=  29
Vehicle=  64  Arrive=  669  Depart=  683  Int.Delay=  14  Tot.Delay=  26
Vehicle=  65  Arrive=  673  Depart=  685  Int.Delay=  12  Tot.Delay=  12
Vehicle=  66  Arrive=  682  Depart=  687  Int.Delay=   5  Tot.Delay=   5
Vehicle=  67  Arrive=  685  Depart=  689  Int.Delay=   4  Tot.Delay=  [illegible]
Vehicle=  68  Arrive=  704  Depart=  704  Int.Delay=   0  Tot.Delay=   0
Vehicle=  69  Arrive=  723  Depart=  738  Int.Delay=  15  Tot.Delay=  15
Vehicle=  70  Arrive=  736  Depart=  740  Int.Delay=   4  Tot.Delay=  23
Vehicle=  71  Arrive=  738  Depart=  742  Int.Delay=   4  Tot.Delay=  21
Vehicle=  72  Arrive=  740  Depart=  744  Int.Delay=   4  Tot.Delay=   5
Vehicle=  73  Arrive=  742  Depart=  746  Int.Delay=   4  Tot.Delay=   4
Vehicle=  74  Arrive=  753  Depart=  753  Int.Delay=   0  Tot.Delay=   0
Vehicle=  75  Arrive=  760  Depart=  760  Int.Delay=   0  Tot.Delay=   0
Vehicle=  76  Arrive=  779  Depart=  803  Int.Delay=  24  Tot.Delay=  24
Vehicle=  77  Arrive=  798  Depart=  805  Int.Delay=   7  Tot.Delay=   7
Vehicle=  78  Arrive=  811  Depart=  811  Int.Delay=   0  Tot.Delay=   2
Vehicle=  79  Arrive=  818  Depart=  818  Int.Delay=   0  Tot.Delay=   0
Vehicle=  80  Arrive=  824  Depart=  824  Int.Delay=   0  Tot.Delay=   0
Vehicle=  81  Arrive=  835  Depart=  835  Int.Delay=   0  Tot.Delay=   0
Vehicle=  82  Arrive=  854  Depart=  854  Int.Delay=   0  Tot.Delay=   0
Vehicle=  83  Arrive=  873  Depart=  873  Int.Delay=   0  Tot.Delay=   0
Vehicle=  84  Arrive=  886  Depart=  886  Int.Delay=   0  Tot.Delay=  42
Vehicle=  85  Arrive=  910  Depart=  920  Int.Delay=  10  Tot.Delay=  10
Vehicle=  86  Arrive=  929  Depart=  929  Int.Delay=   0  Tot.Delay=   0
Vehicle=  87  Arrive=  948  Depart=  948  Int.Delay=   0  Tot.Delay=   0
Vehicle=  88  Arrive=  961  Depart=  985  Int.Delay=  24  Tot.Delay=  68
Vehicle=  89  Arrive=  963  Depart=  987  Int.Delay=  24  Tot.Delay=  59
Vehicle=  90  Arrive=  965  Depart=  989  Int.Delay=  24  Tot.Delay=  52
Vehicle=  91  Arrive=  967  Depart=  991  Int.Delay=  24  Tot.Delay=  51
Vehicle=  92  Arrive=  975  Depart=  993  Int.Delay=  18  Tot.Delay=  18
Vehicle=  93  Arrive=  985  Depart=  995  Int.Delay=  10  Tot.Delay=  12
Vehicle=  94  Arrive= 1004  Depart= 1004  Int.Delay=   0  Tot.Delay=   0
Vehicle=  95  Arrive= 1023  Depart= 1023  Int.Delay=   0  Tot.Delay=   0
Vehicle=  96  Arrive= 1036  Depart= 1051  Int.Delay=  15  Tot.Delay=  62
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Vehicle=   97  Arrive= 1038  Depart= 1053  Int.Delay=   15  Tot.Delay=   55
Vehicle=   98  Arrive= 1040  Depart= 1055  Int.Delay=   15  Tot.Delay=   48
Vehicle=   99  Arrive= 1042  Depart= 1057  Int.Delay=   15  Tot.Delay=   42
Vehicle=  100  Arrive= 1044  Depart= 1059  Int.Delay=   15  Tot.Delay=   27
Vehicle=  101  Arrive= 1060  Depart= 1061  Int.Delay=    1  Tot.Delay=    1
Vehicle=  102  Arrive= 1079  Depart= 1079  Int.Delay=    0  Tot.Delay=    0
Vehicle=  103  Arrive= 1098  Depart= 1116  Int.Delay=   18  Tot.Delay=   18
Vehicle=  104  Arrive= 1111  Depart= 1118  Int.Delay=    7  Tot.Delay=   44
Vehicle=  105  Arrive= 1113  Depart= 1120  Int.Delay=    7  Tot.Delay=   25
Vehicle=  106  Arrive= 1121  Depart= 1122  Int.Delay=    1  Tot.Delay=    1
Vehicle=  107  Arrive= 1132  Depart= 1132  Int.Delay=    0  Tot.Delay=    0
Vehicle=  108  Arrive= 1135  Depart= 1135  Int.Delay=    0  Tot.Delay=    0
Vehicle=  109  Arrive= 1154  Depart= 1154  Int.Delay=    0  Tot.Delay=    0
Vehicle=  110  Arrive= 1173  Depart= 1181  Int.Delay=    8  Tot.Delay=    8
Vehicle=  111  Arrive= 1186  Depart= 1186  Int.Delay=    0  Tot.Delay=   40
Vehicle=  112  Arrive= 1188  Depart= 1188  Int.Delay=    0  Tot.Delay=   36
Vehicle=  113  Arrive= 1209  Depart= 1209  Int.Delay=    0  Tot.Delay=    0
Vehicle=  114  Arrive= 1210  Depart= 1211  Int.Delay=    1  Tot.Delay=    1
Vehicle=  115  Arrive= 1229  Depart= 1246  Int.Delay=   17  Tot.Delay=   17
Vehicle=  116  Arrive= 1248  Depart= 1248  Int.Delay=    0  Tot.Delay=    4
Vehicle=  117  Arrive= 1261  Depart= 1261  Int.Delay=    0  Tot.Delay=   10
Vehicle=  118  Arrive= 1270  Depart= 1270  Int.Delay=    0  Tot.Delay=    0
Vehicle=  119  Arrive= 1278  Depart= 1278  Int.Delay=    0  Tot.Delay=    0
Vehicle=  120  Arrive= 1285  Depart= 1285  Int.Delay=    0  Tot.Delay=    6
Vehicle=  121  Arrive= 1304  Depart= 1311  Int.Delay=    7  Tot.Delay=    7
Vehicle=  122  Arrive= 1323  Depart= 1323  Int.Delay=    0  Tot.Delay=    0
Vehicle=  123  Arrive= 1336  Depart= 1336  Int.Delay=    0  Tot.Delay=   14
Vehicle=  124  Arrive= 1344  Depart= 1344  Int.Delay=    0  Tot.Delay=    0
Vehicle=  125  Arrive= 1348  Depart= 1348  Int.Delay=    0  Tot.Delay=    0
Vehicle=  126  Arrive= 1354  Depart= 1376  Int.Delay=   22  Tot.Delay=   22
Vehicle=  127  Arrive= 1360  Depart= 1378  Int.Delay=   18  Tot.Delay=   32
Vehicle=  128  Arrive= 1379  Depart= 1380  Int.Delay=    1  Tot.Delay=   11
Vehicle=  129  Arrive= 1398  Depart= 1398  Int.Delay=    0  Tot.Delay=    7
Vehicle=  130  Arrive= 1411  Depart= 1411  Int.Delay=    0  Tot.Delay=   47
Vehicle=  131  Arrive= 1413  Depart= 1413  Int.Delay=    0  Tot.Delay=   43
Vehicle=  132  Arrive= 1415  Depart= 1415  Int.Delay=    0  Tot.Delay=   12
Vehicle=  133  Arrive= 1417  Depart= 1441  Int.Delay=   24  Tot.Delay=   33
Vehicle=  134  Arrive= 1423  Depart= 1443  Int.Delay=   20  Tot.Delay=   20
Vehicle=  135  Arrive= 1426  Depart= 1445  Int.Delay=   19  Tot.Delay=   19
Vehicle=  136  Arrive= 1435  Depart= 1447  Int.Delay=   12  Tot.Delay=   23
Vehicle=  137  Arrive= 1454  Depart= 1454  Int.Delay=    0  Tot.Delay=    0
Vehicle=  138  Arrive= 1473  Depart= 1473  Int.Delay=    0  Tot.Delay=    0
Vehicle=  139  Arrive= 1486  Depart= 1506  Int.Delay=   20  Tot.Delay=   63
Vehicle=  140  Arrive= 1488  Depart= 1508  Int.Delay=   20  Tot.Delay=   50
Vehicle=  141  Arrive= 1490  Depart= 1510  Int.Delay=   20  Tot.Delay=   48
Vehicle=  142  Arrive= 1492  Depart= 1512  Int.Delay=   20  Tot.Delay=   29
Vehicle=  143  Arrive= 1494  Depart= 1514  Int.Delay=   20  Tot.Delay=   28
Vehicle=  144  Arrive= 1510  Depart= 1516  Int.Delay=    6  Tot.Delay=   11
Vehicle=  145  Arrive= 1529  Depart= 1529  Int.Delay=    0  Tot.Delay=    9
Vehicle=  146  Arrive= 1548  Depart= 1571  Int.Delay=   23  Tot.Delay=   31
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Vehicle=  147  Arrive= 1561  Depart= 1573  Int.Delay=   12  Tot.Delay=   52
Vehicle=  148  Arrive= 1563  Depart= 1575  Int.Delay=   12  Tot.Delay=   24
Vehicle=  149  Arrive= 1565  Depart= 1577  Int.Delay=   12  Tot.Delay=   23
Vehicle=  150  Arrive= 1585  Depart= 1585  Int.Delay=    0  Tot.Delay=    0
Vehicle=  151  Arrive= 1604  Depart= 1604  Int.Delay=    0  Tot.Delay=   14
Vehicle=  152  Arrive= 1623  Depart= 1636  Int.Delay=   13  Tot.Delay=   13
Vehicle=  153  Arrive= 1636  Depart= 1638  Int.Delay=    2  Tot.Delay=   29
Vehicle=  154  Arrive= 1638  Depart= 1640  Int.Delay=    2  Tot.Delay=   13
Vehicle=  155  Arrive= 1650  Depart= 1650  Int.Delay=    0  Tot.Delay=    0
Vehicle=  156  Arrive= 1656  Depart= 1656  Int.Delay=    0  Tot.Delay=    0
Vehicle=  157  Arrive= 1660  Depart= 1660  Int.Delay=    0  Tot.Delay=   14
Vehicle=  158  Arrive= 1679  Depart= 1701  Int.Delay=   22  Tot.Delay=   26
Vehicle=  159  Arrive= 1698  Depart= 1703  Int.Delay=    5  Tot.Delay=    6
Vehicle=  160  Arrive= 1711  Depart= 1711  Int.Delay=    0  Tot.Delay=   44
Vehicle=  161  Arrive= 1716  Depart= 1716  Int.Delay=    0  Tot.Delay=    0
Vehicle=  162  Arrive= 1722  Depart= 1722  Int.Delay=    0  Tot.Delay=    0
Vehicle=  163  Arrive= 1735  Depart= 1735  Int.Delay=    0  Tot.Delay=   19
Vehicle=  164  Arrive= 1754  Depart= 1766  Int.Delay=   12  Tot.Delay=   27
Vehicle=  165  Arrive= 1773  Depart= 1773  Int.Delay=    0  Tot.Delay=    3
Vehicle=  166  Arrive= 1786  Depart= 1786  Int.Delay=    0  Tot.Delay=   49
Vehicle=  167  Arrive= 1788  Depart= 1788  Int.Delay=    0  Tot.Delay=   45
Vehicle=  168  Arrive= 1790  Depart= 1790  Int.Delay=    0  Tot.Delay=   33
Vehicle=  169  Arrive= 1792  Depart= 1792  Int.Delay=    0  Tot.Delay=   31
Vehicle=  170  Arrive= 1794  Depart= 1794  Int.Delay=    0  Tot.Delay=   16
Vehicle=  171  Arrive= 1796  Depart= 1796  Int.Delay=    0  Tot.Delay=    7
Vehicle=  172  Arrive= 1810  Depart= 1831  Int.Delay=   21  Tot.Delay=   21
Vehicle=  173  Arrive= 1829  Depart= 1833  Int.Delay=    4  Tot.Delay=    4
Vehicle=  174  Arrive= 1848  Depart= 1848  Int.Delay=    0  Tot.Delay=   17
Vehicle=  175  Arrive= 1861  Depart= 1861  Int.Delay=    0  Tot.Delay=   26
Vehicle=  176  Arrive= 1863  Depart= 1863  Int.Delay=    0  Tot.Delay=   24
Vehicle=  177  Arrive= 1865  Depart= 1865  Int.Delay=    0  Tot.Delay=    6
Vehicle=  178  Arrive= 1885  Depart= 1896  Int.Delay=   11  Tot.Delay=   12
Vehicle=  179  Arrive= 1904  Depart= 1904  Int.Delay=    0  Tot.Delay=    0
Vehicle=  180  Arrive= 1923  Depart= 1923  Int.Delay=    0  Tot.Delay=   16
Vehicle=  181  Arrive= 1936  Depart= 1961  Int.Delay=   25  Tot.Delay=   55
Vehicle=  182  Arrive= 1938  Depart= 1963  Int.Delay=   25  Tot.Delay=   49
Vehicle=  183  Arrive= 1940  Depart= 1965  Int.Delay=   25  Tot.Delay=   26
Vehicle=  184  Arrive= 1943  Depart= 1967  Int.Delay=   24  Tot.Delay=   24
Vehicle=  185  Arrive= 1949  Depart= 1969  Int.Delay=   20  Tot.Delay=   20
Vehicle=  186  Arrive= 1957  Depart= 1971  Int.Delay=   14  Tot.Delay=   14
Vehicle=  187  Arrive= 1960  Depart= 1973  Int.Delay=   13  Tot.Delay=   32
Vehicle=  188  Arrive= 1979  Depart= 1979  Int.Delay=    0  Tot.Delay=   16
Vehicle=  189  Arrive= 1998  Depart= 1998  Int.Delay=    0  Tot.Delay=    5
Vehicle=  190  Arrive= 2011  Depart= 2026  Int.Delay=   15  Tot.Delay=   56
Vehicle=  191  Arrive= 2013  Depart= 2028  Int.Delay=   15  Tot.Delay=   15
Vehicle=  192  Arrive= 2026  Depart= 2030  Int.Delay=    4  Tot.Delay=    4
Vehicle=  193  Arrive= 2035  Depart= 2035  Int.Delay=    0  Tot.Delay=    0
Vehicle=  194  Arrive= 2054  Depart= 2054  Int.Delay=    0  Tot.Delay=    0
Vehicle=  195  Arrive= 2073  Depart= 2091  Int.Delay=   18  Tot.Delay=   43
Vehicle=  196  Arrive= 2086  Depart= 2093  Int.Delay=    7  Tot.Delay=   29
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Vehicle=  197  Arrive= 2088  Depart= 2095  Int.Delay=    7  Tot.Delay=   19
Vehicle=  198  Arrive= 2090  Depart= 2097  Int.Delay=    7  Tot.Delay=   12
Vehicle=  199  Arrive= 2110  Depart= 2110  Int.Delay=    0  Tot.Delay=    9
Vehicle=  200  Arrive= 2129  Depart= 2129  Int.Delay=    0  Tot.Delay=   19
Vehicle=  201  Arrive= 2148  Depart= 2156  Int.Delay=    8  Tot.Delay=   27
Vehicle=  202  Arrive= 2161  Depart= 2161  Int.Delay=    0  Tot.Delay=   33
Vehicle=  203  Arrive= 2167  Depart= 2167  Int.Delay=    0  Tot.Delay=    0
Vehicle=  204  Arrive= 2185  Depart= 2185  Int.Delay=    0  Tot.Delay=    0
Vehicle=  205  Arrive= 2204  Depart= 2204  Int.Delay=    0  Tot.Delay=    0
Vehicle=  206  Arrive= 2223  Depart= 2223  Int.Delay=    0  Tot.Delay=    0
Vehicle=  207  Arrive= 2236  Depart= 2236  Int.Delay=    0  Tot.Delay=   10
Vehicle=  208  Arrive= 2260  Depart= 2260  Int.Delay=    0  Tot.Delay=    1
Vehicle=  209  Arrive= 2279  Depart= 2279  Int.Delay=    0  Tot.Delay=    1
Vehicle=  210  Arrive= 2298  Depart= 2305  Int.Delay=    7  Tot.Delay=   30
Vehicle=  211  Arrive= 2311  Depart= 2311  Int.Delay=    0  Tot.Delay=   17
Vehicle=  212  Arrive= 2313  Depart= 2313  Int.Delay=    0  Tot.Delay=   17
Vehicle=  213  Arrive= 2330  Depart= 2330  Int.Delay=    0  Tot.Delay=    0
Vehicle=  214  Arrive= 2333  Depart= 2333  Int.Delay=    0  Tot.Delay=    0
Vehicle=  215  Arrive= 2335  Depart= 2335  Int.Delay=    0  Tot.Delay=   36
Vehicle=  216  Arrive= 2354  Depart= 2370  Int.Delay=   16  Tot.Delay=   50
Vehicle=  217  Arrive= 2373  Depart= 2373  Int.Delay=    0  Tot.Delay=   20
Vehicle=  218  Arrive= 2386  Depart= 2386  Int.Delay=    0  Tot.Delay=   47
Vehicle=  219  Arrive= 2388  Depart= 2388  Int.Delay=    0  Tot.Delay=   45
Vehicle=  220  Arrive= 2390  Depart= 2390  Int.Delay=    0  Tot.Delay=   31
Vehicle=  221  Arrive= 2392  Depart= 2392  Int.Delay=    0  Tot.Delay=   28
Vehicle=  222  Arrive= 2405  Depart= 2405  Int.Delay=    0  Tot.Delay=    0
Vehicle=  223  Arrive= 2409  Depart= 2409  Int.Delay=    0  Tot.Delay=    0
Vehicle=  224  Arrive= 2410  Depart= 2411  Int.Delay=    1  Tot.Delay=   12
Vehicle=  225  Arrive= 2429  Depart= 2429  Int.Delay=    0  Tot.Delay=    6
Vehicle=  226  Arrive= 2448  Depart= 2448  Int.Delay=    0  Tot.Delay=    3
Vehicle=  227  Arrive= 2461  Depart= 2461  Int.Delay=    0  Tot.Delay=   19
Vehicle=  228  Arrive= 2463  Depart= 2463  Int.Delay=    0  Tot.Delay=   14
Vehicle=  229  Arrive= 2465  Depart= 2465  Int.Delay=    0  Tot.Delay=   11
Vehicle=  230  Arrive= 2485  Depart= 2492  Int.Delay=    7  Tot.Delay=   38
Vehicle=  231  Arrive= 2504  Depart= 2504  Int.Delay=    0  Tot.Delay=    0
Vehicle=  232  Arrive= 2523  Depart= 2523  Int.Delay=    0  Tot.Delay=   40
Vehicle=  233  Arrive= 2536  Depart= 2557  Int.Delay=   21  Tot.Delay=   63
Vehicle=  234  Arrive= 2545  Depart= 2559  Int.Delay=   14  Tot.Delay=   14
Vehicle=  235  Arrive= 2552  Depart= 2561  Int.Delay=    9  Tot.Delay=    9
Vehicle=  236  Arrive= 2560  Depart= 2563  Int.Delay=    3  Tot.Delay=   47
Vehicle=  237  Arrive= 2579  Depart= 2579  Int.Delay=    0  Tot.Delay=   32
Vehicle=  238  Arrive= 2598  Depart= 2622  Int.Delay=   24  Tot.Delay=   59
Vehicle=  239  Arrive= 2611  Depart= 2624  Int.Delay=   13  Tot.Delay=   62
Vehicle=  240  Arrive= 2613  Depart= 2626  Int.Delay=   13  Tot.Delay=   50
Vehicle=  241  Arrive= 2635  Depart= 2635  Int.Delay=    0  Tot.Delay=   45
Vehicle=  242  Arrive= 2654  Depart= 2654  Int.Delay=    0  Tot.Delay=    0
Vehicle=  243  Arrive= 2673  Depart= 2687  Int.Delay=   14  Tot.Delay=   14
Vehicle=  244  Arrive= 2686  Depart= 2689  Int.Delay=    3  Tot.Delay=   52
Vehicle=  245  Arrive= 2694  Depart= 2694  Int.Delay=    0  Tot.Delay=    0
Vehicle=  246  Arrive= 2698  Depart= 2698  Int.Delay=    0  Tot.Delay=    0
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Vehicle=  247  Arrive= 2710  Depart= 2710  Int.Delay=   0  Tot.Delay=  41
Vehicle=  248  Arrive= 2729  Depart= 2752  Int.Delay=  23  Tot.Delay=  38
Vehicle=  249  Arrive= 2748  Depart= 2754  Int.Delay=   6  Tot.Delay=  10
Vehicle=  250  Arrive= 2761  Depart= 2761  Int.Delay=   0  Tot.Delay=  42
Vehicle=  251  Arrive= 2763  Depart= 2763  Int.Delay=   0  Tot.Delay=  15
Vehicle=  252  Arrive= 2765  Depart= 2765  Int.Delay=   0  Tot.Delay=   4
Vehicle=  253  Arrive= 2777  Depart= 2777  Int.Delay=   0  Tot.Delay=   0
Vehicle=  254  Arrive= 2785  Depart= 2785  Int.Delay=   0  Tot.Delay=  31
Vehicle=  255  Arrive= 2804  Depart= 2817  Int.Delay=  13  Tot.Delay=  22
Vehicle=  256  Arrive= 2823  Depart= 2823  Int.Delay=   0  Tot.Delay=   8
Vehicle=  257  Arrive= 2836  Depart= 2836  Int.Delay=   0  Tot.Delay=  30
Vehicle=  258  Arrive= 2838  Depart= 2838  Int.Delay=   0  Tot.Delay=   7
Vehicle=  259  Arrive= 2840  Depart= 2840  Int.Delay=   0  Tot.Delay=   6
Vehicle=  260  Arrive= 2857  Depart= 2882  Int.Delay=  25  Tot.Delay=  25
Vehicle=  261  Arrive= 2860  Depart= 2884  Int.Delay=  24  Tot.Delay=  51
Vehicle=  262  Arrive= 2879  Depart= 2886  Int.Delay=   7  Tot.Delay=  34
Vehicle=  263  Arrive= 2898  Depart= 2898  Int.Delay=   0  Tot.Delay=   9
Vehicle=  264  Arrive= 2911  Depart= 2911  Int.Delay=   0  Tot.Delay=  24
Vehicle=  265  Arrive= 2913  Depart= 2913  Int.Delay=   0  Tot.Delay=  24
Vehicle=  266  Arrive= 2915  Depart= 2915  Int.Delay=   0  Tot.Delay=   6
Vehicle=  267  Arrive= 2917  Depart= 2917  Int.Delay=   0  Tot.Delay=   5
Vehicle=  268  Arrive= 2919  Depart= 2919  Int.Delay=   0  Tot.Delay=   3
Vehicle=  269  Arrive= 2935  Depart= 2947  Int.Delay=  12  Tot.Delay=  26
Vehicle=  270  Arrive= 2954  Depart= 2954  Int.Delay=   0  Tot.Delay=  43
Vehicle=  271  Arrive= 2973  Depart= 2973  Int.Delay=   0  Tot.Delay=  17
Vehicle=  272  Arrive= 2986  Depart= 2986  Int.Delay=   0  Tot.Delay=  50
Vehicle=  273  Arrive= 2988  Depart= 3012  Int.Delay=  24  Tot.Delay=  65
Vehicle=  274  Arrive= 2990  Depart= 3014  Int.Delay=  24  Tot.Delay=  39
Vehicle=  275  Arrive= 2992  Depart= 3016  Int.Delay=  24  Tot.Delay=  38
Vehicle=  276  Arrive= 2997  Depart= 3018  Int.Delay=  21  Tot.Delay=  21
Vehicle=  277  Arrive= 3000  Depart= 3020  Int.Delay=  20  Tot.Delay=  20
Vehicle=  278  Arrive= 3002  Depart= 3022  Int.Delay=  20  Tot.Delay=  20
Vehicle=  279  Arrive= 3007  Depart= 3024  Int.Delay=  17  Tot.Delay=  17
Vehicle=  280  Arrive= 3010  Depart= 3026  Int.Delay=  16  Tot.Delay=  37
Vehicle=  281  Arrive= 3029  Depart= 3029  Int.Delay=   0  Tot.Delay=   1
Vehicle=  282  Arrive= 3048  Depart= 3048  Int.Delay=   0  Tot.Delay=   0
Vehicle=  283  Arrive= 3061  Depart= 3077  Int.Delay=  16  Tot.Delay=  32
Vehicle=  284  Arrive= 3067  Depart= 3079  Int.Delay=  12  Tot.Delay=  12
Vehicle=  285  Arrive= 3080  Depart= 3081  Int.Delay=   1  Tot.Delay=   1
Vehicle=  286  Arrive= 3085  Depart= 3085  Int.Delay=   0  Tot.Delay=  47
Vehicle=  287  Arrive= 3104  Depart= 3104  Int.Delay=   0  Tot.Delay=  39
Vehicle=  288  Arrive= 3123  Depart= 3142  Int.Delay=  19  Tot.Delay=  54
Vehicle=  289  Arrive= 3136  Depart= 3144  Int.Delay=   8  Tot.Delay=  49
Vehicle=  290  Arrive= 3138  Depart= 3146  Int.Delay=   8  Tot.Delay=  41
Vehicle=  291  Arrive= 3140  Depart= 3148  Int.Delay=   8  Tot.Delay=  37
Vehicle=  292  Arrive= 3142  Depart= 3150  Int.Delay=   8  Tot.Delay=  23
Vehicle=  293  Arrive= 3144  Depart= 3152  Int.Delay=   8  Tot.Delay=  15
Vehicle=  294  Arrive= 3152  Depart= 3154  Int.Delay=   2  Tot.Delay=   2
Vehicle=  295  Arrive= 3160  Depart= 3160  Int.Delay=   0  Tot.Delay=  31
Vehicle=  296  Arrive= 3179  Depart= 3179  Int.Delay=   0  Tot.Delay=  17
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Vehicle= 297  Arrive= 3198  Depart= 3207  Int.Delay=   9  Tot.Delay=   9
Vehicle= 298  Arrive= 3211  Depart= 3211  Int.Delay=   0  Tot.Delay=  51
Vehicle= 299  Arrive= 3213  Depart= 3213  Int.Delay=   0  Tot.Delay=  11
Vehicle= 300  Arrive= 3222  Depart= 3222  Int.Delay=   0  Tot.Delay=   0
Vehicle= 301  Arrive= 3235  Depart= 3235  Int.Delay=   0  Tot.Delay=  27
Vehicle= 302  Arrive= 3254  Depart= 3272  Int.Delay=  18  Tot.Delay=  32
Vehicle= 303  Arrive= 3273  Depart= 3274  Int.Delay=   1  Tot.Delay=   6
Vehicle= 304  Arrive= 3286  Depart= 3286  Int.Delay=   0  Tot.Delay=  17
Vehicle= 305  Arrive= 3288  Depart= 3288  Int.Delay=   0  Tot.Delay=   4
Vehicle= 306  Arrive= 3295  Depart= 3295  Int.Delay=   0  Tot.Delay=   0
Vehicle= 307  Arrive= 3306  Depart= 3306  Int.Delay=   0  Tot.Delay=   0
Vehicle= 308  Arrive= 3310  Depart= 3310  Int.Delay=   0  Tot.Delay=   0
Vehicle= 309  Arrive= 3329  Depart= 3341  Int.Delay=  12  Tot.Delay=  51
Vehicle= 310  Arrive= 3348  Depart= 3348  Int.Delay=   0  Tot.Delay=   6
Vehicle= 311  Arrive= 3361  Depart= 3361  Int.Delay=   0  Tot.Delay=  46
Vehicle= 312  Arrive= 3363  Depart= 3363  Int.Delay=   0  Tot.Delay=  30
Vehicle= 313  Arrive= 3369  Depart= 3369  Int.Delay=   0  Tot.Delay=   0
Vehicle= 314  Arrive= 3385  Depart= 3406  Int.Delay=  21  Tot.Delay=  23
Vehicle= 315  Arrive= 3404  Depart= 3408  Int.Delay=   4  Tot.Delay=  52
Vehicle= 316  Arrive= 3423  Depart= 3423  Int.Delay=   0  Tot.Delay=  38
Vehicle= 317  Arrive= 3436  Depart= 3436  Int.Delay=   0  Tot.Delay=  47
Vehicle= 318  Arrive= 3438  Depart= 3438  Int.Delay=   0  Tot.Delay=  38
Vehicle= 319  Arrive= 3440  Depart= 3440  Int.Delay=   0  Tot.Delay=  28
Vehicle= 320  Arrive= 3456  Depart= 3471  Int.Delay=  15  Tot.Delay=  15
Vehicle= 321  Arrive= 3460  Depart= 3473  Int.Delay=  13  Tot.Delay=  54
Vehicle= 322  Arrive= 3479  Depart= 3479  Int.Delay=   0  Tot.Delay=   7
Vehicle= 323  Arrive= 3498  Depart= 3498  Int.Delay=   0  Tot.Delay=  24
Vehicle= 324  Arrive= 3511  Depart= 3536  Int.Delay=  25  Tot.Delay=  51
Vehicle= 325  Arrive= 3522  Depart= 3538  Int.Delay=  16  Tot.Delay=  16
Vehicle= 326  Arrive= 3535  Depart= 3540  Int.Delay=   5  Tot.Delay=  20
Vehicle= 327  Arrive= 3554  Depart= 3554  Int.Delay=   0  Tot.Delay=  42
Vehicle= 328  Arrive= 3573  Depart= 3573  Int.Delay=   0  Tot.Delay=  41
 Average Intersection Vehicle Delay =   6.00
 Average Total Vehicle Delay        =  20.00
Vehicle=   1  Arrive=   21  Depart=   69  Int.Delay=  48  Tot.Delay=  48
Vehicle=   2  Arrive=   40  Depart=   71  Int.Delay=  31  Tot.Delay=  31
Vehicle=   3  Arrive=   59  Depart=   73  Int.Delay=  14  Tot.Delay=  14
Vehicle=   4  Arrive=   90  Depart=   90  Int.Delay=   0  Tot.Delay=  58
Vehicle=   5  Arrive=   92  Depart=   92  Int.Delay=   0  Tot.Delay=  37
Vehicle=   6  Arrive=   94  Depart=   94  Int.Delay=   0  Tot.Delay=  35
Vehicle=   7  Arrive=   96  Depart=   96  Int.Delay=   0  Tot.Delay=   7
Vehicle=   8  Arrive=   98  Depart=  129  Int.Delay=  31  Tot.Delay=  34
Vehicle=   9  Arrive=  114  Depart=  131  Int.Delay=  17  Tot.Delay=  17
Vehicle=  10  Arrive=  155  Depart=  155  Int.Delay=   0  Tot.Delay=  22
Vehicle=  11  Arrive=  157  Depart=  189  Int.Delay=  32  Tot.Delay=  74
Vehicle=  12  Arrive=  159  Depart=  191  Int.Delay=  32  Tot.Delay=  72
Vehicle=  13  Arrive=  161  Depart=  193  Int.Delay=  32  Tot.Delay=  41
Vehicle=  14  Arrive=  170  Depart=  195  Int.Delay=  25  Tot.Delay=  25
Vehicle=  15  Arrive=  189  Depart=  197  Int.Delay=   8  Tot.Delay=   8
Vehicle=  16  Arrive=  220  Depart=  249  Int.Delay=  29  Tot.Delay=  41
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Vehicle=   17  Arrive=  222  Depart=  251  Int.Delay=   29  Tot.Delay=   80
Vehicle=   18  Arrive=  224  Depart=  253  Int.Delay=   29  Tot.Delay=   59
Vehicle=   19  Arrive=  226  Depart=  255  Int.Delay=   29  Tot.Delay=   55
Vehicle=   20  Arrive=  228  Depart=  257  Int.Delay=   29  Tot.Delay=   45
Vehicle=   21  Arrive=  230  Depart=  259  Int.Delay=   29  Tot.Delay=   40
Vehicle=   22  Arrive=  241  Depart=  261  Int.Delay=   20  Tot.Delay=   20
Vehicle=   23  Arrive=  245  Depart=  263  Int.Delay=   18  Tot.Delay=   18
Vehicle=   24  Arrive=  285  Depart=  309  Int.Delay=   24  Tot.Delay=   45
Vehicle=   25  Arrive=  287  Depart=  311  Int.Delay=   24  Tot.Delay=   28
Vehicle=   26  Arrive=  296  Depart=  313  Int.Delay=   17  Tot.Delay=   31
Vehicle=   27  Arrive=  298  Depart=  315  Int.Delay=   17  Tot.Delay=   21
Vehicle=   28  Arrive=  313  Depart=  317  Int.Delay=    4  Tot.Delay=    4
Vehicle=   29  Arrive=  320  Depart=  320  Int.Delay=    0  Tot.Delay=    0
Vehicle=   30  Arrive=  350  Depart=  369  Int.Delay=   19  Tot.Delay=   30
Vehicle=   31  Arrive=  358  Depart=  371  Int.Delay=   13  Tot.Delay=   13
Vehicle=   32  Arrive=  371  Depart=  373  Int.Delay=    2  Tot.Delay=   47
Vehicle=   33  Arrive=  373  Depart=  375  Int.Delay=    2  Tot.Delay=   46
Vehicle=   34  Arrive=  375  Depart=  377  Int.Delay=    2  Tot.Delay=   27
Vehicle=   35  Arrive=  377  Depart=  379  Int.Delay=    2  Tot.Delay=   27
Vehicle=   36  Arrive=  379  Depart=  381  Int.Delay=    2  Tot.Delay=   19
Vehicle=   37  Arrive=  381  Depart=  383  Int.Delay=    2  Tot.Delay=   16
Vehicle=   38  Arrive=  383  Depart=  385  Int.Delay=    2  Tot.Delay=    9
Vehicle=   39  Arrive=  415  Depart=  429  Int.Delay=   14  Tot.Delay=   34
Vehicle=   40  Arrive=  417  Depart=  431  Int.Delay=   14  Tot.Delay=   17
Vehicle=   41  Arrive=  433  Depart=  433  Int.Delay=    0  Tot.Delay=    0
Vehicle=   42  Arrive=  446  Depart=  446  Int.Delay=    0  Tot.Delay=   38
Vehicle=   43  Arrive=  448  Depart=  448  Int.Delay=    0  Tot.Delay=   33
Vehicle=   44  Arrive=  450  Depart=  450  Int.Delay=    0  Tot.Delay=    3
Vehicle=   45  Arrive=  480  Depart=  489  Int.Delay=    9  Tot.Delay=   21
Vehicle=   46  Arrive=  482  Depart=  491  Int.Delay=    9  Tot.Delay=   21
Vehicle=   47  Arrive=  489  Depart=  493  Int.Delay=    4  Tot.Delay=    4
Vehicle=   48  Arrive=  508  Depart=  508  Int.Delay=    0  Tot.Delay=    0
Vehicle=   49  Arrive=  545  Depart=  549  Int.Delay=    4  Tot.Delay=   47
Vehicle=   50  Arrive=  547  Depart=  551  Int.Delay=    4  Tot.Delay=    6
Vehicle=   51  Arrive=  564  Depart=  564  Int.Delay=    0  Tot.Delay=    0
Vehicle=   52  Arrive=  583  Depart=  609  Int.Delay=   26  Tot.Delay=   26
Vehicle=   53  Arrive=  618  Depart=  618  Int.Delay=    0  Tot.Delay=   70
Vehicle=   54  Arrive=  620  Depart=  620  Int.Delay=    0  Tot.Delay=   46
Vehicle=   55  Arrive=  622  Depart=  622  Int.Delay=    0  Tot.Delay=   44
Vehicle=   56  Arrive=  624  Depart=  624  Int.Delay=    0  Tot.Delay=   22
Vehicle=   57  Arrive=  626  Depart=  626  Int.Delay=    0  Tot.Delay=    6
Vehicle=   58  Arrive=  639  Depart=  669  Int.Delay=   30  Tot.Delay=   30
Vehicle=   59  Arrive=  683  Depart=  683  Int.Delay=    0  Tot.Delay=   25
Vehicle=   60  Arrive=  685  Depart=  685  Int.Delay=    0  Tot.Delay=   43
Vehicle=   61  Arrive=  687  Depart=  687  Int.Delay=    0  Tot.Delay=   37
Vehicle=   62  Arrive=  689  Depart=  689  Int.Delay=    0  Tot.Delay=   37
Vehicle=   63  Arrive=  691  Depart=  691  Int.Delay=    0  Tot.Delay=   29
Vehicle=   64  Arrive=  693  Depart=  693  Int.Delay=    0  Tot.Delay=   26
Vehicle=   65  Arrive=  695  Depart=  695  Int.Delay=    0  Tot.Delay=   12
Vehicle=   66  Arrive=  697  Depart=  729  Int.Delay=   32  Tot.Delay=   37
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Vehicle=   67  Arrive=  699  Depart=  731  Int.Delay=   32  Tot.Delay=   36
Vehicle=   68  Arrive=  714  Depart=  733  Int.Delay=   19  Tot.Delay=   19
Vehicle=   69  Arrive=  748  Depart=  748  Int.Delay=    0  Tot.Delay=   15
Vehicle=   70  Arrive=  750  Depart=  750  Int.Delay=    0  Tot.Delay=   23
Vehicle=   71  Arrive=  752  Depart=  752  Int.Delay=    0  Tot.Delay=   21
Vehicle=   72  Arrive=  754  Depart=  754  Int.Delay=    0  Tot.Delay=    5
Vehicle=   73  Arrive=  756  Depart=  756  Int.Delay=    0  Tot.Delay=    4
Vehicle=   74  Arrive=  763  Depart=  789  Int.Delay=   26  Tot.Delay=   26
Vehicle=   75  Arrive=  770  Depart=  791  Int.Delay=   21  Tot.Delay=   21
Vehicle=   76  Arrive=  813  Depart=  813  Int.Delay=    0  Tot.Delay=   24
Vehicle=   77  Arrive=  815  Depart=  815  Int.Delay=    0  Tot.Delay=    7
Vehicle=   78  Arrive=  821  Depart=  849  Int.Delay=   28  Tot.Delay=   30
Vehicle=   79  Arrive=  828  Depart=  851  Int.Delay=   23  Tot.Delay=   23
Vehicle=   80  Arrive=  834  Depart=  853  Int.Delay=   19  Tot.Delay=   19
Vehicle=   81  Arrive=  845  Depart=  855  Int.Delay=   10  Tot.Delay=   10
Vehicle=   82  Arrive=  864  Depart=  864  Int.Delay=    0  Tot.Delay=    0
Vehicle=   83  Arrive=  883  Depart=  909  Int.Delay=   26  Tot.Delay=   26
Vehicle=   84  Arrive=  896  Depart=  911  Int.Delay=   15  Tot.Delay=   57
Vehicle=   85  Arrive=  930  Depart=  930  Int.Delay=    0  Tot.Delay=   10
Vehicle=   86  Arrive=  939  Depart=  969  Int.Delay=   30  Tot.Delay=   30
Vehicle=   87  Arrive=  958  Depart=  971  Int.Delay=   13  Tot.Delay=   13
Vehicle=   88  Arrive=  995  Depart=  995  Int.Delay=    0  Tot.Delay=   68
Vehicle=   89  Arrive=  997  Depart= 1029  Int.Delay=   32  Tot.Delay=   91
Vehicle=   90  Arrive=  999  Depart= 1031  Int.Delay=   32  Tot.Delay=   84
Vehicle=   91  Arrive= 1001  Depart= 1033  Int.Delay=   32  Tot.Delay=   83
Vehicle=   92  Arrive= 1003  Depart= 1035  Int.Delay=   32  Tot.Delay=   50
Vehicle=   93  Arrive= 1005  Depart= 1037  Int.Delay=   32  Tot.Delay=   44
Vehicle=   94  Arrive= 1014  Depart= 1039  Int.Delay=   25  Tot.Delay=   25
Vehicle=   95  Arrive= 1033  Depart= 1041  Int.Delay=    8  Tot.Delay=    8
Vehicle=   96  Arrive= 1061  Depart= 1089  Int.Delay=   28  Tot.Delay=   90
Vehicle=   97  Arrive= 1063  Depart= 1091  Int.Delay=   28  Tot.Delay=   83
Vehicle=   98  Arrive= 1065  Depart= 1093  Int.Delay=   28  Tot.Delay=   76
Vehicle=   99  Arrive= 1067  Depart= 1095  Int.Delay=   28  Tot.Delay=   70
Vehicle=  100  Arrive= 1069  Depart= 1097  Int.Delay=   28  Tot.Delay=   55
Vehicle=  101  Arrive= 1071  Depart= 1099  Int.Delay=   28  Tot.Delay=   29
Vehicle=  102  Arrive= 1089  Depart= 1101  Int.Delay=   12  Tot.Delay=   12
Vehicle=  103  Arrive= 1126  Depart= 1149  Int.Delay=   23  Tot.Delay=   41
Vehicle=  104  Arrive= 1128  Depart= 1151  Int.Delay=   23  Tot.Delay=   67
Vehicle=  105  Arrive= 1130  Depart= 1153  Int.Delay=   23  Tot.Delay=   48
Vehicle=  106  Arrive= 1132  Depart= 1155  Int.Delay=   23  Tot.Delay=   24
Vehicle=  107  Arrive= 1142  Depart= 1157  Int.Delay=   15  Tot.Delay=   15
Vehicle=  108  Arrive= 1145  Depart= 1159  Int.Delay=   14  Tot.Delay=   14
Vehicle=  109  Arrive= 1164  Depart= 1164  Int.Delay=    0  Tot.Delay=    0
Vehicle=  110  Arrive= 1191  Depart= 1209  Int.Delay=   18  Tot.Delay=   26
Vehicle=  111  Arrive= 1196  Depart= 1211  Int.Delay=   15  Tot.Delay=   55
Vehicle=  112  Arrive= 1198  Depart= 1213  Int.Delay=   15  Tot.Delay=   51
Vehicle=  113  Arrive= 1219  Depart= 1219  Int.Delay=    0  Tot.Delay=    0
Vehicle=  114  Arrive= 1221  Depart= 1221  Int.Delay=    0  Tot.Delay=    1
Vehicle=  115  Arrive= 1256  Depart= 1269  Int.Delay=   13  Tot.Delay=   30
Vehicle=  116  Arrive= 1258  Depart= 1271  Int.Delay=   13  Tot.Delay=   17
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Vehicle=  117  Arrive= 1271  Depart= 1273  Int.Delay=    2  Tot.Delay=   12
Vehicle=  118  Arrive= 1280  Depart= 1280  Int.Delay=    0  Tot.Delay=    0
Vehicle=  119  Arrive= 1288  Depart= 1288  Int.Delay=    0  Tot.Delay=    0
Vehicle=  120  Arrive= 1295  Depart= 1295  Int.Delay=    0  Tot.Delay=    6
Vehicle=  121  Arrive= 1321  Depart= 1329  Int.Delay=    8  Tot.Delay=   15
Vehicle=  122  Arrive= 1333  Depart= 1333  Int.Delay=    0  Tot.Delay=    0
Vehicle=  123  Arrive= 1346  Depart= 1346  Int.Delay=    0  Tot.Delay=   14
Vehicle=  124  Arrive= 1354  Depart= 1354  Int.Delay=    0  Tot.Delay=    0
Vehicle=  125  Arrive= 1358  Depart= 1389  Int.Delay=   31  Tot.Delay=   31
Vehicle=  126  Arrive= 1386  Depart= 1391  Int.Delay=    5  Tot.Delay=   27
Vehicle=  127  Arrive= 1388  Depart= 1393  Int.Delay=    5  Tot.Delay=   37
Vehicle=  128  Arrive= 1390  Depart= 1395  Int.Delay=    5  Tot.Delay=   16
Vehicle=  129  Arrive= 1408  Depart= 1408  Int.Delay=    0  Tot.Delay=    7
Vehicle=  130  Arrive= 1421  Depart= 1449  Int.Delay=   28  Tot.Delay=   75
Vehicle=  131  Arrive= 1423  Depart= 1451  Int.Delay=   28  Tot.Delay=   71
Vehicle=  132  Arrive= 1425  Depart= 1453  Int.Delay=   28  Tot.Delay=   40
Vehicle=  133  Arrive= 1451  Depart= 1455  Int.Delay=    4  Tot.Delay=   37
Vehicle=  134  Arrive= 1453  Depart= 1457  Int.Delay=    4  Tot.Delay=   24
Vehicle=  135  Arrive= 1455  Depart= 1459  Int.Delay=    4  Tot.Delay=   23
Vehicle=  136  Arrive= 1457  Depart= 1461  Int.Delay=    4  Tot.Delay=   27
Vehicle=  137  Arrive= 1464  Depart= 1464  Int.Delay=    0  Tot.Delay=    0
Vehicle=  138  Arrive= 1483  Depart= 1509  Int.Delay=   26  Tot.Delay=   26
Vehicle=  139  Arrive= 1516  Depart= 1516  Int.Delay=    0  Tot.Delay=   63
Vehicle=  140  Arrive= 1518  Depart= 1518  Int.Delay=    0  Tot.Delay=   50
Vehicle=  141  Arrive= 1520  Depart= 1520  Int.Delay=    0  Tot.Delay=   48
Vehicle=  142  Arrive= 1522  Depart= 1522  Int.Delay=    0  Tot.Delay=   29
Vehicle=  143  Arrive= 1524  Depart= 1524  Int.Delay=    0  Tot.Delay=   28
Vehicle=  144  Arrive= 1526  Depart= 1526  Int.Delay=    0  Tot.Delay=   11
Vehicle=  145  Arrive= 1539  Depart= 1569  Int.Delay=   30  Tot.Delay=   39
Vehicle=  146  Arrive= 1581  Depart= 1581  Int.Delay=    0  Tot.Delay=   31
Vehicle=  147  Arrive= 1583  Depart= 1583  Int.Delay=    0  Tot.Delay=   52
Vehicle=  148  Arrive= 1585  Depart= 1585  Int.Delay=    0  Tot.Delay=   24
Vehicle=  149  Arrive= 1587  Depart= 1587  Int.Delay=    0  Tot.Delay=   23
Vehicle=  150  Arrive= 1595  Depart= 1595  Int.Delay=    0  Tot.Delay=    0
Vehicle=  151  Arrive= 1614  Depart= 1629  Int.Delay=   15  Tot.Delay=   29
Vehicle=  152  Arrive= 1646  Depart= 1646  Int.Delay=    0  Tot.Delay=   13
Vehicle=  153  Arrive= 1648  Depart= 1648  Int.Delay=    0  Tot.Delay=   29
Vehicle=  154  Arrive= 1650  Depart= 1650  Int.Delay=    0  Tot.Delay=   13
Vehicle=  155  Arrive= 1660  Depart= 1689  Int.Delay=   29  Tot.Delay=   29
Vehicle=  156  Arrive= 1666  Depart= 1691  Int.Delay=   25  Tot.Delay=   25
Vehicle=  157  Arrive= 1670  Depart= 1693  Int.Delay=   23  Tot.Delay=   37
Vehicle=  158  Arrive= 1711  Depart= 1711  Int.Delay=    0  Tot.Delay=   26
Vehicle=  159  Arrive= 1713  Depart= 1713  Int.Delay=    0  Tot.Delay=    6
Vehicle=  160  Arrive= 1721  Depart= 1749  Int.Delay=   28  Tot.Delay=   72
Vehicle=  161  Arrive= 1726  Depart= 1751  Int.Delay=   25  Tot.Delay=   25
Vehicle=  162  Arrive= 1732  Depart= 1753  Int.Delay=   21  Tot.Delay=   21
Vehicle=  163  Arrive= 1745  Depart= 1755  Int.Delay=   10  Tot.Delay=   29
Vehicle=  164  Arrive= 1776  Depart= 1776  Int.Delay=    0  Tot.Delay=   27
Vehicle=  165  Arrive= 1783  Depart= 1809  Int.Delay=   26  Tot.Delay=   29
Vehicle=  166  Arrive= 1796  Depart= 1811  Int.Delay=   15  Tot.Delay=   64
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Vehicle=  167  Arrive= 1798  Depart= 1813  Int.Delay=   15  Tot.Delay=   60
Vehicle=  168  Arrive= 1800  Depart= 1815  Int.Delay=   15  Tot.Delay=   48
Vehicle=  169  Arrive= 1802  Depart= 1817  Int.Delay=   15  Tot.Delay=   46
Vehicle=  170  Arrive= 1804  Depart= 1819  Int.Delay=   15  Tot.Delay=   31
Vehicle=  171  Arrive= 1806  Depart= 1821  Int.Delay=   15  Tot.Delay=   22
Vehicle=  172  Arrive= 1841  Depart= 1869  Int.Delay=   28  Tot.Delay=   49
Vehicle=  173  Arrive= 1843  Depart= 1871  Int.Delay=   28  Tot.Delay=   32
Vehicle=  174  Arrive= 1858  Depart= 1873  Int.Delay=   15  Tot.Delay=   32
Vehicle=  175  Arrive= 1871  Depart= 1875  Int.Delay=    4  Tot.Delay=   30
Vehicle=  176  Arrive= 1873  Depart= 1877  Int.Delay=    4  Tot.Delay=   28
Vehicle=  177  Arrive= 1875  Depart= 1879  Int.Delay=    4  Tot.Delay=   10
Vehicle=  178  Arrive= 1906  Depart= 1929  Int.Delay=   23  Tot.Delay=   35
Vehicle=  179  Arrive= 1914  Depart= 1931  Int.Delay=   17  Tot.Delay=   17
Vehicle=  180  Arrive= 1933  Depart= 1933  Int.Delay=    0  Tot.Delay=   16
Vehicle=  181  Arrive= 1971  Depart= 1989  Int.Delay=   18  Tot.Delay=   73
Vehicle=  182  Arrive= 1973  Depart= 1991  Int.Delay=   18  Tot.Delay=   67
Vehicle=  183  Arrive= 1975  Depart= 1993  Int.Delay=   18  Tot.Delay=   44
Vehicle=  184  Arrive= 1977  Depart= 1995  Int.Delay=   18  Tot.Delay=   42
Vehicle=  185  Arrive= 1979  Depart= 1997  Int.Delay=   18  Tot.Delay=   38
Vehicle=  186  Arrive= 1981  Depart= 1999  Int.Delay=   18  Tot.Delay=   32
Vehicle=  187  Arrive= 1983  Depart= 2001  Int.Delay=   18  Tot.Delay=   50
Vehicle=  188  Arrive= 1989  Depart= 2003  Int.Delay=   14  Tot.Delay=   30
Vehicle=  189  Arrive= 2008  Depart= 2008  Int.Delay=    0  Tot.Delay=    5
Vehicle=  190  Arrive= 2036  Depart= 2049  Int.Delay=   13  Tot.Delay=   69
Vehicle=  191  Arrive= 2038  Depart= 2051  Int.Delay=   13  Tot.Delay=   28
Vehicle=  192  Arrive= 2040  Depart= 2053  Int.Delay=   13  Tot.Delay=   17
Vehicle=  193  Arrive= 2045  Depart= 2055  Int.Delay=   10  Tot.Delay=   10
Vehicle=  194  Arrive= 2064  Depart= 2064  Int.Delay=    0  Tot.Delay=    0
Vehicle=  195  Arrive= 2101  Depart= 2109  Int.Delay=    8  Tot.Delay=   51
Vehicle=  196  Arrive= 2103  Depart= 2111  Int.Delay=    8  Tot.Delay=   37
Vehicle=  197  Arrive= 2105  Depart= 2113  Int.Delay=    8  Tot.Delay=   27
Vehicle=  198  Arrive= 2107  Depart= 2115  Int.Delay=    8  Tot.Delay=   20
Vehicle=  199  Arrive= 2120  Depart= 2120  Int.Delay=    0  Tot.Delay=    9
Vehicle=  200  Arrive= 2139  Depart= 2169  Int.Delay=   30  Tot.Delay=   49
Vehicle=  201  Arrive= 2166  Depart= 2171  Int.Delay=    5  Tot.Delay=   32
Vehicle=  202  Arrive= 2171  Depart= 2173  Int.Delay=    2  Tot.Delay=   35
Vehicle=  203  Arrive= 2177  Depart= 2177  Int.Delay=    0  Tot.Delay=    0
Vehicle=  204  Arrive= 2195  Depart= 2195  Int.Delay=    0  Tot.Delay=    0
Vehicle=  205  Arrive= 2214  Depart= 2229  Int.Delay=   15  Tot.Delay=   15
Vehicle=  206  Arrive= 2233  Depart= 2233  Int.Delay=    0  Tot.Delay=    0
Vehicle=  207  Arrive= 2246  Depart= 2246  Int.Delay=    0  Tot.Delay=   10
Vehicle=  208  Arrive= 2270  Depart= 2289  Int.Delay=   19  Tot.Delay=   20
Vehicle=  209  Arrive= 2289  Depart= 2291  Int.Delay=    2  Tot.Delay=    3
Vehicle=  210  Arrive= 2315  Depart= 2315  Int.Delay=    0  Tot.Delay=   30
Vehicle=  211  Arrive= 2321  Depart= 2349  Int.Delay=   28  Tot.Delay=   45
Vehicle=  212  Arrive= 2323  Depart= 2351  Int.Delay=   28  Tot.Delay=   45
Vehicle=  213  Arrive= 2340  Depart= 2353  Int.Delay=   13  Tot.Delay=   13
Vehicle=  214  Arrive= 2343  Depart= 2355  Int.Delay=   12  Tot.Delay=   12
Vehicle=  215  Arrive= 2345  Depart= 2357  Int.Delay=   12  Tot.Delay=   48
Vehicle=  216  Arrive= 2380  Depart= 2409  Int.Delay=   29  Tot.Delay=   79
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Vehicle=  217  Arrive= 2383  Depart= 2411  Int.Delay=   28  Tot.Delay=   48
Vehicle=  218  Arrive= 2396  Depart= 2413  Int.Delay=   17  Tot.Delay=   64
Vehicle=  219  Arrive= 2398  Depart= 2415  Int.Delay=   17  Tot.Delay=   62
Vehicle=  220  Arrive= 2400  Depart= 2417  Int.Delay=   17  Tot.Delay=   48
Vehicle=  221  Arrive= 2402  Depart= 2419  Int.Delay=   17  Tot.Delay=   45
Vehicle=  222  Arrive= 2415  Depart= 2421  Int.Delay=    6  Tot.Delay=    6
Vehicle=  223  Arrive= 2419  Depart= 2423  Int.Delay=    4  Tot.Delay=    4
Vehicle=  224  Arrive= 2421  Depart= 2425  Int.Delay=    4  Tot.Delay=   16
Vehicle=  225  Arrive= 2439  Depart= 2469  Int.Delay=   30  Tot.Delay=   36
Vehicle=  226  Arrive= 2458  Depart= 2471  Int.Delay=   13  Tot.Delay=   16
Vehicle=  227  Arrive= 2471  Depart= 2473  Int.Delay=    2  Tot.Delay=   21
Vehicle=  228  Arrive= 2473  Depart= 2475  Int.Delay=    2  Tot.Delay=   16
Vehicle=  229  Arrive= 2475  Depart= 2477  Int.Delay=    2  Tot.Delay=   13
Vehicle=  230  Arrive= 2502  Depart= 2529  Int.Delay=   27  Tot.Delay=   65
Vehicle=  231  Arrive= 2514  Depart= 2531  Int.Delay=   17  Tot.Delay=   17
Vehicle=  232  Arrive= 2533  Depart= 2533  Int.Delay=    0  Tot.Delay=   40
Vehicle=  233  Arrive= 2567  Depart= 2589  Int.Delay=   22  Tot.Delay=   85
Vehicle=  234  Arrive= 2569  Depart= 2591  Int.Delay=   22  Tot.Delay=   36
Vehicle=  235  Arrive= 2571  Depart= 2593  Int.Delay=   22  Tot.Delay=   31
Vehicle=  236  Arrive= 2573  Depart= 2595  Int.Delay=   22  Tot.Delay=   69
Vehicle=  237  Arrive= 2589  Depart= 2597  Int.Delay=    8  Tot.Delay=   40
Vehicle=  238  Arrive= 2632  Depart= 2649  Int.Delay=   17  Tot.Delay=   76
Vehicle=  239  Arrive= 2634  Depart= 2651  Int.Delay=   17  Tot.Delay=   79
Vehicle=  240  Arrive= 2636  Depart= 2653  Int.Delay=   17  Tot.Delay=   67
Vehicle=  241  Arrive= 2645  Depart= 2655  Int.Delay=   10  Tot.Delay=   55
Vehicle=  242  Arrive= 2664  Depart= 2664  Int.Delay=    0  Tot.Delay=    0
Vehicle=  243  Arrive= 2697  Depart= 2709  Int.Delay=   12  Tot.Delay=   26
Vehicle=  244  Arrive= 2699  Depart= 2711  Int.Delay=   12  Tot.Delay=   64
Vehicle=  245  Arrive= 2704  Depart= 2713  Int.Delay=    9  Tot.Delay=    9
Vehicle=  246  Arrive= 2708  Depart= 2715  Int.Delay=    7  Tot.Delay=    7
Vehicle=  247  Arrive= 2720  Depart= 2720  Int.Delay=    0  Tot.Delay=   41
Vehicle=  248  Arrive= 2762  Depart= 2769  Int.Delay=    7  Tot.Delay=   45
Vehicle=  249  Arrive= 2764  Depart= 2771  Int.Delay=    7  Tot.Delay=   17
Vehicle=  250  Arrive= 2771  Depart= 2773  Int.Delay=    2  Tot.Delay=   44
Vehicle=  251  Arrive= 2773  Depart= 2775  Int.Delay=    2  Tot.Delay=   17
Vehicle=  252  Arrive= 2775  Depart= 2777  Int.Delay=    2  Tot.Delay=    6
Vehicle=  253  Arrive= 2787  Depart= 2787  Int.Delay=    0  Tot.Delay=    0
Vehicle=  254  Arrive= 2795  Depart= 2795  Int.Delay=    0  Tot.Delay=   31
Vehicle=  255  Arrive= 2827  Depart= 2829  Int.Delay=    2  Tot.Delay=   24
Vehicle=  256  Arrive= 2833  Depart= 2833  Int.Delay=    0  Tot.Delay=    8
Vehicle=  257  Arrive= 2846  Depart= 2846  Int.Delay=    0  Tot.Delay=   30
Vehicle=  258  Arrive= 2848  Depart= 2848  Int.Delay=    0  Tot.Delay=    7
Vehicle=  259  Arrive= 2850  Depart= 2850  Int.Delay=    0  Tot.Delay=    6
Vehicle=  260  Arrive= 2892  Depart= 2892  Int.Delay=    0  Tot.Delay=   25
Vehicle=  261  Arrive= 2894  Depart= 2894  Int.Delay=    0  Tot.Delay=   51
Vehicle=  262  Arrive= 2896  Depart= 2896  Int.Delay=    0  Tot.Delay=   34
Vehicle=  263  Arrive= 2908  Depart= 2908  Int.Delay=    0  Tot.Delay=    9
Vehicle=  264  Arrive= 2921  Depart= 2949  Int.Delay=   28  Tot.Delay=   52
Vehicle=  265  Arrive= 2923  Depart= 2951  Int.Delay=   28  Tot.Delay=   52
Vehicle=  266  Arrive= 2925  Depart= 2953  Int.Delay=   28  Tot.Delay=   34
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Vehicle=  267  Arrive= 2927  Depart= 2955  Int.Delay=   28  Tot.Delay=   33
Vehicle=  268  Arrive= 2929  Depart= 2957  Int.Delay=   28  Tot.Delay=   31
Vehicle=  269  Arrive= 2957  Depart= 2959  Int.Delay=    2  Tot.Delay=   28
Vehicle=  270  Arrive= 2964  Depart= 2964  Int.Delay=    0  Tot.Delay=   43
Vehicle=  271  Arrive= 2983  Depart= 3009  Int.Delay=   26  Tot.Delay=   43
Vehicle=  272  Arrive= 2996  Depart= 3011  Int.Delay=   15  Tot.Delay=   65
Vehicle=  273  Arrive= 3022  Depart= 3022  Int.Delay=    0  Tot.Delay=   65
Vehicle=  274  Arrive= 3024  Depart= 3024  Int.Delay=    0  Tot.Delay=   39
Vehicle=  275  Arrive= 3026  Depart= 3026  Int.Delay=    0  Tot.Delay=   38
Vehicle=  276  Arrive= 3028  Depart= 3028  Int.Delay=    0  Tot.Delay=   21
Vehicle=  277  Arrive= 3030  Depart= 3030  Int.Delay=    0  Tot.Delay=   20
Vehicle=  278  Arrive= 3032  Depart= 3032  Int.Delay=    0  Tot.Delay=   20
Vehicle=  279  Arrive= 3034  Depart= 3034  Int.Delay=    0  Tot.Delay=   17
Vehicle=  280  Arrive= 3036  Depart= 3036  Int.Delay=    0  Tot.Delay=   37
Vehicle=  281  Arrive= 3039  Depart= 3069  Int.Delay=   30  Tot.Delay=   31
Vehicle=  282  Arrive= 3058  Depart= 3071  Int.Delay=   13  Tot.Delay=   13
Vehicle=  283  Arrive= 3087  Depart= 3087  Int.Delay=    0  Tot.Delay=   32
Vehicle=  284  Arrive= 3089  Depart= 3089  Int.Delay=    0  Tot.Delay=   12
Vehicle=  285  Arrive= 3091  Depart= 3091  Int.Delay=    0  Tot.Delay=    1
Vehicle=  286  Arrive= 3095  Depart= 3095  Int.Delay=    0  Tot.Delay=   47
Vehicle=  287  Arrive= 3114  Depart= 3129  Int.Delay=   15  Tot.Delay=   54
Vehicle=  288  Arrive= 3152  Depart= 3152  Int.Delay=    0  Tot.Delay=   54
Vehicle=  289  Arrive= 3154  Depart= 3154  Int.Delay=    0  Tot.Delay=   49
Vehicle=  290  Arrive= 3156  Depart= 3156  Int.Delay=    0  Tot.Delay=   41
Vehicle=  291  Arrive= 3158  Depart= 3189  Int.Delay=   31  Tot.Delay=   68
Vehicle=  292  Arrive= 3160  Depart= 3191  Int.Delay=   31  Tot.Delay=   54
Vehicle=  293  Arrive= 3162  Depart= 3193  Int.Delay=   31  Tot.Delay=   46
Vehicle=  294  Arrive= 3164  Depart= 3195  Int.Delay=   31  Tot.Delay=   33
Vehicle=  295  Arrive= 3170  Depart= 3197  Int.Delay=   27  Tot.Delay=   58
Vehicle=  296  Arrive= 3189  Depart= 3199  Int.Delay=   10  Tot.Delay=   27
Vehicle=  297  Arrive= 3217  Depart= 3249  Int.Delay=   32  Tot.Delay=   41
Vehicle=  298  Arrive= 3221  Depart= 3251  Int.Delay=   30  Tot.Delay=   81
Vehicle=  299  Arrive= 3223  Depart= 3253  Int.Delay=   30  Tot.Delay=   41
Vehicle=  300  Arrive= 3232  Depart= 3255  Int.Delay=   23  Tot.Delay=   23
Vehicle=  301  Arrive= 3245  Depart= 3257  Int.Delay=   12  Tot.Delay=   39
Vehicle=  302  Arrive= 3282  Depart= 3309  Int.Delay=   27  Tot.Delay=   59
Vehicle=  303  Arrive= 3284  Depart= 3311  Int.Delay=   27  Tot.Delay=   33
Vehicle=  304  Arrive= 3296  Depart= 3313  Int.Delay=   17  Tot.Delay=   34
Vehicle=  305  Arrive= 3298  Depart= 3315  Int.Delay=   17  Tot.Delay=   21
Vehicle=  306  Arrive= 3305  Depart= 3317  Int.Delay=   12  Tot.Delay=   12
Vehicle=  307  Arrive= 3316  Depart= 3319  Int.Delay=    3  Tot.Delay=    3
Vehicle=  308  Arrive= 3320  Depart= 3321  Int.Delay=    1  Tot.Delay=    1
Vehicle=  309  Arrive= 3351  Depart= 3369  Int.Delay=   18  Tot.Delay=   69
Vehicle=  310  Arrive= 3358  Depart= 3371  Int.Delay=   13  Tot.Delay=   19
Vehicle=  311  Arrive= 3371  Depart= 3373  Int.Delay=    2  Tot.Delay=   48
Vehicle=  312  Arrive= 3373  Depart= 3375  Int.Delay=    2  Tot.Delay=   32
Vehicle=  313  Arrive= 3379  Depart= 3379  Int.Delay=    0  Tot.Delay=    0
Vehicle=  314  Arrive= 3416  Depart= 3429  Int.Delay=   13  Tot.Delay=   36
Vehicle=  315  Arrive= 3418  Depart= 3431  Int.Delay=   13  Tot.Delay=   65
Vehicle=  316  Arrive= 3433  Depart= 3433  Int.Delay=    0  Tot.Delay=   38
```

```
Vehicle=  317  Arrive= 3446  Depart= 3446  Int.Delay=    0  Tot.Delay=   47
Vehicle=  318  Arrive= 3448  Depart= 3448  Int.Delay=    0  Tot.Delay=   38
Vehicle=  319  Arrive= 3450  Depart= 3450  Int.Delay=    0  Tot.Delay=   28
Vehicle=  320  Arrive= 3481  Depart= 3489  Int.Delay=    8  Tot.Delay=   23
Vehicle=  321  Arrive= 3483  Depart= 3491  Int.Delay=    8  Tot.Delay=   62
Vehicle=  322  Arrive= 3489  Depart= 3493  Int.Delay=    4  Tot.Delay=   11
Vehicle=  323  Arrive= 3508  Depart= 3508  Int.Delay=    0  Tot.Delay=   24
Vehicle=  324  Arrive= 3546  Depart= 3549  Int.Delay=    3  Tot.Delay=   54
Vehicle=  325  Arrive= 3548  Depart= 3551  Int.Delay=    3  Tot.Delay=   19
Vehicle=  326  Arrive= 3550  Depart= 3553  Int.Delay=    3  Tot.Delay=   23
Vehicle=  327  Arrive= 3564  Depart= 3564  Int.Delay=    0  Tot.Delay=   42
 Average Intersection Vehicle Delay =  11.00
 Average Total Vehicle Delay        =  31.00
```

```
               PEDXING PROGRAM - TIME SPACE DIAGRAM PLOT

     INTERSECTION #1                           CROSSWALK                             INTERSECTION #2
TIME ARRIVE   DEPART                        ARRIVE    DEPART                        ARRIVE    DEPART
1043    :          :                            :          :                            :          :
1042    :          :                            :          :                            :          :
1041    :          :                            :          :                            :        95S
1040    :          :                            :          :                            :          :
1039    :          :                            :          :                            :        94S
1038    :          :                            :          :                            :          :
1037    :          :                            :          :                            :          :
1036    :          :                            :          :                            :          :
1035    :          :                            :          :                            :          :
1034    :          :                            :          :                            :          :
1033    :          :                            :          :                          95S          :
1032    :          :                            :          :                            :          :
1031    :          :                            :          :                            :          :
1030    :          :                            :          :                            :          :
1029    :          :                            :          :                            :          :
1028    :          :                            :          :                            :          :
1027    :          :                            :          :                            :          :
1026    :          :                            :          :                            :          :
1025    :          :                            :          :                            :          :
1024    :          :                            :          :                            :          :
1023    :          :                          95S        95S                            :          :
1022    :          :                            :          :                            :          :
1021    :          :                            :          :                            :          :
1020    :          :                            :          :                            :          :
1019    :          :                            :          :                            :          :
1018    :          :                            :          :                            :          :
1017    :          :                            :          :                            :          :
1016    :          :                            :          :                            :          :
1015    :          :                            :          :                            :          :
1014    :          :                            :          :                          94S          :
1013  95S        95S                            :          :                            :          :
1012    :          :                            :          :                            :          :
1011    :          :                            :          :                            :          :
1010    :          :                            :          :                            :          :
1009    :          :                            :          :                            :          :
1008    :          :                            :          :                            :          :
1007    :          :                            :          :                            :          :
1006    :          :                            :          :                            :          :
1005    :          :                            :          :                            :          :
1004    :          :                          94S        94S                            :          :
1003    :          :                            :          :                            :          :
1002    :          :                            :          :                            :          :
1001    :          :                            :          :                            :          :
1000    :          :                            :          :                            :          :
 999    :          :                            :          :                            :          :
 998    :          :                            :          :                            :          :
 997    :          :                            :          :                            :          :
 996    :          :                            :          :                            :          :
 995    :          :                            :          :                            :          :
 994  94S        94S                            :          :                            :          :
 993    :          :                            :          :                            :          :
 992    :          :                            :          :                            :          :
```